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# DEPARTMENT OF DEFENSE
## ELECTROMAGNETIC COMPATIBILITY ANALYSIS CENTER

# AVIONICS INTERFERENCE PREDICTION MODEL (U)

Prepared by G. Morgan
of the IIT Research Institute

December 1970

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Technical Report

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## FOREWORD

The Electromagnetic Compatibility Analysis Center (ECAC) is a Department of Defense facility, established to provide advice and assistance on electromagnetic compatibility matters to the Secretary of Defense, the Joint Chiefs of Staff, the military departments and other DOD components. The Center, located at North Severn, Annapolis, Maryland 21402, is under executive control of the Director of Defense Research and Engineering and the Chairman, Joint Chiefs of Staff or their designees who jointly provide policy guidance, assign projects, and establish priorities. ECAC functions under the direction of the Secretary of the Air Force and the management and technical direction of the Center are provided by military and civil service personnel. The technical operations function is provided through an Air Force sponsored contract with the IIT Research Institute (IITRI).

This report was prepared for the Federal Aviation Administration in accordance with Task assignment 2 of Interagency Agreement DOT-FA70WAI-175 as part of AF Project 649E under Contract F19628-70-C-0291 by the staff of the IIT Research Institute at the Department of Defense Electromagnetic Compatibility Analysis Center.

To the extent possible, all abbreviations and symbols used in this report are taken from American Standard Y10.19 (1967) "Units Used in Electrical Science and Electrical Engineering" issued by the United States of America Standards Institute.

Users of this report are invited to submit comments which would be useful in revising or adding to this material to the Director, ECAC, North Severn, Annapolis, Maryland 21402, Attention ACV.

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## ABSTRACT

An interference prediction model developed for use in evaluating expected interactions between avionics equipments on an airplane is described. The model is substantially automated and includes subroutines which calculate expected path losses between aircraft antennas and the rejection offered by the receivers to the undesired emissions from transmitters on the aircraft.

An analysis of the interactions between the equipments installed on an FAA Sabreliner has been made using the prediction model and the results of the analysis are described.

Requirements for expansion of the prediction model are established.

## KEYWORDS

ANTENNA COUPLING
AIRFRAME COUPLING
SABRELINER AIRCRAFT
COSITE
PERFORMANCE MODELS

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# SECTION 1

# INTRODUCTION

## BACKGROUND

The Federal Aviation Administration (FAA) has established a requirement for the development of a general analytical capability to determine the mutual effects resulting from the introduction of new avionics equipment to an existing airframe containing operational equipment. Accordingly, the Electromagnetic Compatibility Analysis Center (ECAC) (See Reference 1) agreed to develop an analytical modular model capability for the FAA which will enable rapid evaluation of these effects as the need arises.

In accordance with the specified agreement, the ECAC was to develop the capability to evaluate the mutual effects of the avionics packages associated with the FAA Sabreliner aircraft, specifically, and then to generalize the resulting models such that they may be applied to any other airframe/avionics configuration.

The FAA Sabreliner is a specially equipped aircraft used to monitor and evaluate performance of ground-based electronic navigational aids in the United States. The complement of radio and navigational equipment associated with the Sabreliner is summarized in TABLE 3-1. These were the specific units treated in this initial development.

## OBJECTIVES

The objectives of this program were to:

a. Develop an automated airframe coupling model.

b. Develop performance models for the Sabreliner avionics equipment and, where possible, generalize these models to enable application to other similar types of equipment.

c. Establish requirements for future modeling activity.

d. Perform an analysis of the FAA Sabreliner so that it may be used as a validation model for the developed analytical capability.

e. Determine the expected mutual effects resulting from the installation of a VHF Satcom terminal on the Sabreliner.

## CONSTRAINTS

The interference prediction model reported herein considers only antenna coupled interference. Interactions due to cable coupled interference, and effects due to interference radiated directly between equipments on the airplane, are not considered.

# SECTION 2

# RESULTS AND CONCLUSIONS

## RESULTS

1. A modularized antenna coupled interference prediction model was developed which is substantially automated.

2. The program includes an automated coupling model which predicts the path losses between antennas on an airframe and an automated subroutine which calculates the effective rejection offered to undesired signals by the receiving systems.

3. An analysis was made of the expected mutual effects between the avionics equipments aboard the FAA Sabreliner flight inspection aircraft.

4. The expected effects resulting from the installation of an additional system, a proposed VHF Satellite Communications (SATCOM) terminal, were evaluated.

5. A test plan for validation of the predicted coupling losses was proposed.

## CONCLUSIONS

1. The existing avionics complement aboard the Sabreliner is capable of compatible operations, provided the frequency relationships identified in Section 5 are avoided. (See Section 5).

2. A VHF SATCOM terminal may be added to the Sabreliner complement without adverse effects, provided its operating frequency is above 133 MHz. (See Section 5).

3. The prediction model described herein is amenable to expansion and generalization to enable solution of situations involving aircraft-to-aircraft and aircraft-to-ground environment equipment as well as the intra-aircraft problem for which it was designed.

# SECTION 3

# ANALYSIS

## SABRELINER DESCRIPTION

The FAA Sabreliner aircraft is a special version of the North American Rockwell Series 40 Sabreliner which has been equipped as a flight inspection facility. The radio and navigation equipment associated with the aircraft is summarized in TABLE 3-1.

TABLE 3-1
SABRELINER EQUIPMENT COMPLEMENT

| Equipment | Quantity | Manufacturer | Function |
|---|---|---|---|
| RTA-41B | 2 | Bendix | VHF Communications |
| DF-203 | 2 | Collins | Automatic Direction Finding |
| 51Z-4 | 1 | Collins | Marker Beacon Receiver |
| WP-103A | 1 | Collins | Weather Radar |
| AVQ-65 | 1 | RCA | ATCRBS Transponder |
| DRA-12 | 1 | Bendix | Doppler Navigation Radar |
| RNA-26CF | 3 | Bendix | VOR/LOC Receivers |
| ALA-51 | 1 | Bendix | Radio Altimeter |
| AN/ARC-109 | 1 | Collins | UHF Communications |
| 618T-3 | 1 | Collins | HF Communications |
| RT-870/ARN-91 | 2 | Hoffman | TACAN System |

An illustration of the Sabreliner indicating the location and description of the antennas associated with these systems is shown in Figure 3-1.

### Analysis Techniques

The analysis of the mutual effects of the operation of the equipment on the Sabreliner, including the analysis done by the automated computer model developed to assist in the effort, was accomplished by predicting the expected level of degradation relative to the degradation threshold of each receiver. The procedure used in the prediction process is

ANTENNA DESCRIPTIONS

| Antenna No. | Frame No. | Description | Antenna No. | Frame No. | Description |
|---|---|---|---|---|---|
| 1 | 24 | Weather Radar | 9 | 190 | Doppler Radar |
| 2 | 8 | Glide Slope | 10 | 324 | Marker Beacon |
| 3 | 44 | TACAN | 11 | 340, 370 | Altimeter |
| 4 | 43 | ATC Transponder | 12 | 377 | TACAN |
| 5 | 110 | TACAN | 13 | 438 | UHF-DF |
| 6 | 135 | UHF/VHF Comm. | 14 | 482 | VHF-Navigation |
| 7 | 146 | TACAN | 15 | 509 | VHF-Navigation |
| 8 | 168 | VHF Comm. | | | |

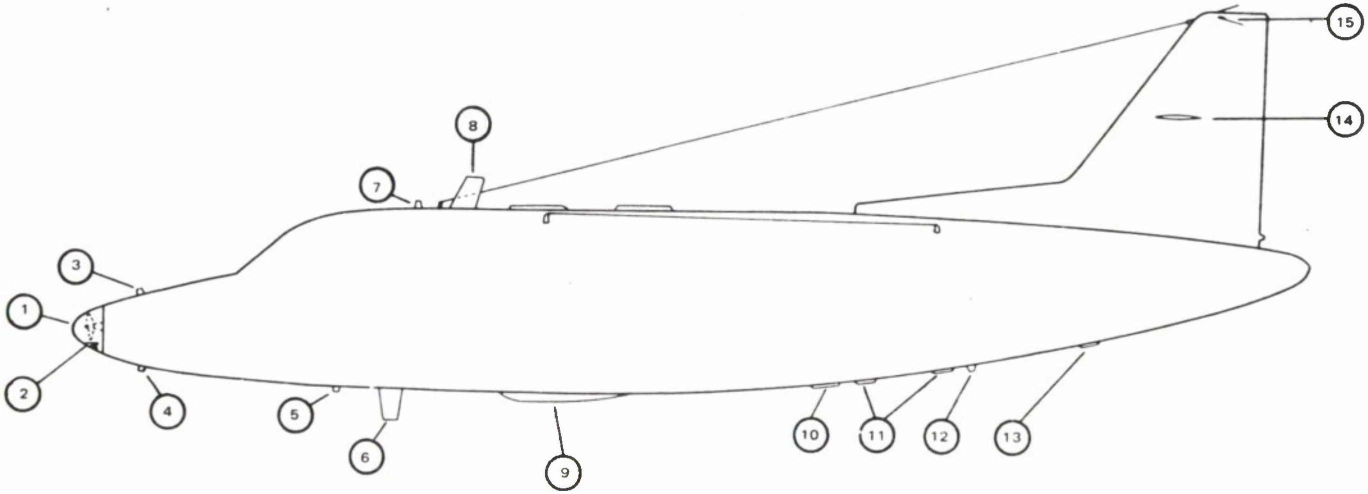


Figure 3-1. FAA Sabreliner Antenna Complement.

described below. Units for frequency and bandwidth, unless otherwise stated, are the same.

The undesired interfering power at the input terminals of a potential victim receiver can be calculated with the logarithmic form of the one-way system loss equation which is:

$$P_i = P_T + G_T + G_R - L_p - L_s \qquad (3\text{-}1)$$

where;

$P_i$ = the input interfering power in decibels relative to one milliwatt (dBm).

$P_T$ = the transmitter output power in dBm.

$G_T$ = the effective gain of the transmitting antenna in the direction of the receiving antenna in dB relative to an isotropic radiator (dBi).

$G_R$ = the effective gain of the receiving antenna in the direction of the transmitting antenna in dB relative to an isotropic radiator.

$L_p$ = the path loss between isotropic radiators in dB.

$L_s$ = the combined system losses associated with the transmitter and receiver due to transmission lines, coupling devices, and external RF filtering in dB.

In the interest of conservatism, the system losses can usually be neglected without introducing significant errors. It was assumed herein that such losses are negligible. Therefore, the $L_s$ term was dropped from further consideration at this time, but the capability to include such a factor has been retained for future application.

The effect of this interfering power depends on the response characteristics of the receiver circuitry prior to the detector and the input signal-to-interference ratio ($S/_I$) required by the receiver to perform without degradation in the presence of such an

interfering signal. This effect can be represented by:

$$R = A - L_f \tag{3-2}$$

where:

$R$ = the response of the receiver circuitry to the input interfering signal in dB.

$A$ = the response of the receiver to its desired signal in dB.

$L_f$ = the response to the interfering signal relative to the response to the desired signal offered by the receiver in dB, i.e., the rejection offered by the receiver to the undesired signal.

If equation (3-2) is normalized to A and combined with (3-1), then

$$P_{ie} = P_T + G_T + G_R - L_p - L_f \tag{3-3}$$

where:

$P_{ie}$ = the effective input interfering signal in dBm, which has been normalized relative to an undesired signal with the same characteristics as the desired signal.

In other words, the minimum level of an input desired signal required to produce a standard response is defined as the receiver sensitivity. If the interfering signal has different characteristics than the desired signal, the input level required to produce a standard response is different. This difference in levels can be considered as an on-tune receiver rejection factor for the interfering signal. The consideration of this factor with any additional off-frequency rejection resulting from the selectivity characteristic of the receiver can be considered as a total receiver rejection factor for the interfering signal.

The level of degradation caused by this signal can be evaluated by comparing the resulting signal-to-interference ratio to the required threshold $S/_I$ ratio. If it is assumed that the input desired signal is at the receiver sensitivity level, then the degradation level is:

$$P_{Id} = P_{ie} - R_s + (S/_I)_T \tag{3-4}$$

where:

$P_{Id}$ = the degradation level relative to the threshold of the degradation in dB.

$R_s$ = the sensitivity of the receiver in dBm.

$(S/_I)_T$ = the threshold input signal-to-interference ratio, in dB, required to prevent degradation.

If equations (3-3) and (3-4) are combined, then

$$P_{Id} = P_T + G_T + G_R - L_p - L_f + (S/_I)_T - R_s \tag{3-5}$$

where all of the terms have been defined.

If $P_{Id}$ is greater than zero, then degradation is expected to occur; conversely, if $P_{Id}$ is less than zero, degradation is not expected and further consideration need not be given to interactions between the particular transmitter and receiver involved.

Equation (3-5) is the expression solved by the analyst when studying a potential interference problem and by the developed automated program up to the point where a detailed manual analysis is required. Each of the terms in equation (3-5) is discussed below.

### Transmitted Power, $P_T$

This parameter is a required input to the program and represents the average output power in dBm for communications transmitters and the peak output power for pulsed transmitters. This information can be obtained from the nominal characteristics of the equipment or from measured data.

### Antenna Gains, $G_T$, $G_R$

These parameters are also required inputs to the program at the present time and they represent the expected gain to be realized along the propagation path between the antennas on the airframe. It is important to note that, since the area of consideration is confined to the intra-aircraft problem; the perturbations in the antenna patterns observed at great

distances from the aircraft, which are caused by irregularities in the airframe shape, are not expected to be realized. Further, since it is difficult, if not impossible, to measure the radiation pattern of antennas when the observation points as well as the antennas are located on the same aircraft, the values recommended for use in the program are the maximum theoretical values to be expected along the surface of the airframe in the direction of the transmission path between the antennas under consideration.

For non-aperture types of surface mounted antennas, such as monopoles, dipoles, blades, and loop antennas, the gain to be used is the maximum theoretical gain in the horizontal plane.

For aperture type antennas, such as parabolic reflectors, phased arrays, and horns, whose direction of maximum radiation is broadside to the airframe, the appropriate value to be used for the antenna gain is the value in the sidelobe or backlobe which is directed along the surface of the aircraft.

Certain of the values to be used can be obtained from manufacturer's data. When it is necessary to calculate the value theoretically, the expressions to be used can be obtained from References 2 and 3. The antenna gains used in this analysis are shown in TABLE 3-2. These gain characteristics are expected to be representative of most of the antennas used on airplanes for the indicated functions.

The specification of the antenna gains as required inputs for the automated model is consistent with the modular concept and enables greater flexibility for generalization of the prediction program. For example, if, in the future, the model is expanded to enable evaluation of mutual effects in inter-aircraft and aircraft-to-ground equipment considerations, an antenna gain calculation subroutine could be developed and included in the overall model. Such a subroutine could either be deterministic or statistical.

### Path Loss, $L_p$

The path loss between isotropic radiators on an airframe is calculated using the technique reported by Hasserjian and Ishimaru (See Reference 4) and extended by Khan et al (See Reference 5). These efforts have shown that the path loss along a conducting curved surface can be calculated by:

$$L_{pc} = L_{pf} \; F(y) \qquad (3\text{-}6)$$

## TABLE 3-2
## INPUT ANTENNA GAINS

| Antenna No. | Function | Type | Polarization | Gain (dBi) |
|---|---|---|---|---|
| 1 | Weather Radar | Parabolic | Horizontal | −10 |
| 2 | Glide Slope | Dipole | Horizontal | 2 |
| 3 | TACAN | Blade | Vertical | 2 |
| 4 | ATC | Blade | Vertical | 2 |
| 5 | TACAN | Blade | Vertical | 2 |
| 6 | VHF/UHF Comm. | Blade | Vertical | 2 |
| 7 | TACAN | Blade | Vertical | 2 |
| 8 | UHF Comm. | Blade | Vertical | 2 |
| 9 | Doppler Radar | Array | Linear | −20 |
| 10 | Marker Beacon | Loop | Horizontal | − 5 |
| 11 | Altimeter | Horn | Horizontal | −20 |
| 12 | TACAN | Blade | Vertical | 2 |
| 13 | UHF-DF | Loop | Vertical | 2 |
| 14 | VOR/ILS | Loop | Horizontal | 2 |
| 15 | VOR/ILS | Dipole | Horizontal | 2 |

where;

$L_{pc}$ = the path loss along the curved surface of the airframe.

$L_{pf}$ = the path loss along the same surface when flattened into a plane.

$F(y)$ = the loss factor due to the curvature of the surface, i.e., the curvature factor.

The curvature factor, F(y), is a complex infinite series in y which depends on the geometrical parameters of the path (See Reference 5).

The function y is:

$$y = R_1^{3/2}/\rho_1 \qquad (3\text{-}7)$$

where:

$R_1$ = the length of the curved ray path as normalized by the wave number, i.e. $R_1$ equals k times $D_1$, where $D_1$ is the curved ray path and $k = 2\pi/\lambda$, where λ is the wavelength.

$\rho_1$ = the curvature of the ray path as normalized by the wave number.

The parameter y is described below for various geometrical shapes found in practical airframes:

$$y = K^{1/2}\ a\ \phi^2 \Big/ \left[(\Delta Z)^2 + (a\phi)^2\right]^{1/4} \ \text{for a cylinder;} \qquad (3\text{-}7a)$$

$$y = (Ka)^{1/2}\ \phi^{3/2} \ \text{for a sphere,} \qquad (3\text{-}7b)$$

$$y \cong K^{1/2}\ (a_i a_j)^{1/2}\ \phi^2 \Big/ \left[(\Delta Z)^2 + a_i a_j\ \phi^2\right]^{1/4} \ \text{for a cone,} \qquad (3\text{-}7c)$$

where:

a = the radius of the cylinder or sphere.

$a_i$ = the radius of the cone at the ith antenna location.

$a_j$ = the radius of the cone at the jth antenna location.

$\Delta Z$ = the distance between the antennas along the axis of the cylinder or cone.

$\phi$ = the angle in radians between the antennas on a plane defined by the two antennas and the center of the airframe.

The coordinate system used in describing these parameters and the solution of the magnitude of F(y) versus y in decibels are shown in Figure 3-2.

The path loss between the antennas on the surface when it has been flattened into a plane is calculated using the free space formula:

$$L_{pf} = 20 \log f_{MHz} + 20 \log D_1 - 38 \qquad (3\text{-}8)$$

where

$L_{pf}$ = the free space loss between isotropic radiators in dB.

$f_{MHz}$ = the transmitted frequency in megahertz (MHz).

$D_1$ = the ray path distance along the surface between the antennas in feet.

The distance, $D_1$, for the various geometrical shapes is:

$$D_1 = a\phi \text{ for a sphere,} \qquad (3\text{-}9a)$$

$$D_1 = \left[ (\Delta Z)^2 + (a\phi)^2 \right]^{1/2} \text{ for a cylinder,} \qquad (3\text{-}9b)$$

$$D_1 \cong \left[ (\Delta Z)^2 + a_i a_j \phi^2 \right]^{1/2} \text{ for a cone,} \qquad (3\text{-}9c)$$

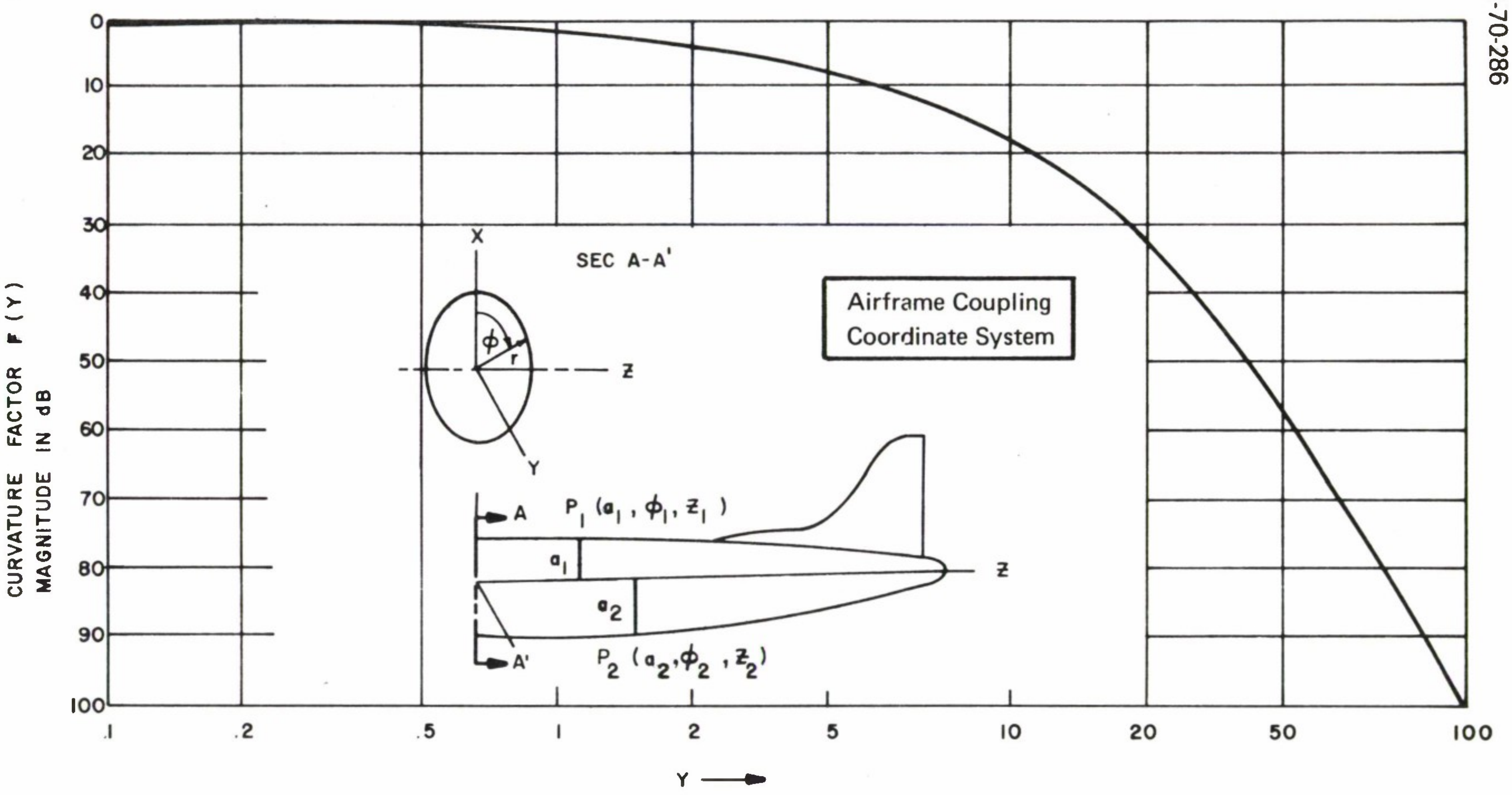


Figure 3-2. Curvature Factor, F(y) versus y.

where all of the terms have previously been defined.

It should be noted that the expressions shown for an airframe shaped like a conical cylinder, are approximations rather than exact relationships. The reason for this situation is that one of the restrictions in the technical development of the curvature factor is a requirement that the curvature along the ray path between the antennas remain constant. When the antennas lie on a conical surface, this requirement is not completely satisfied. In practical airframes, however, it can be shown that the ray path length can be calculated with a high degree of accuracy by treating the cone as a modified cylinder with a radius equal to the geometric mean of the radii of the cone at the locations of the antennas. The limitation of this approximation is that the apex angle of the cone cannot exceed 20 degrees. This limitation is satisfied for the Sabreliner where the apex angle is approximately 14 degrees. This result leads intuitively to the finding that the curvature factor between two antennas on a cone lies between those factors which would be calculated if the cone were replaced by two cylinders having radii equal to the cone radii at each of the two antennas.

When this type of computation is made for the worst case situation found on the Sabreliner, it is found that the theoretical error to be expected in the total coupling loss lies in the range of 0 - 2dB. This minimal error occurs when determining the total loss between the VHF antenna mounted on the top centerline and the UHF direction-finding antenna mounted on the bottom centerline.

The remaining restrictions which affect the application of this technique include geometrical limitations which insure that the respective antennas do not lie within each others Fresnel (near-field) region. These geometrical restrictions place a lower limit on the frequencies at which the coupling loss can be calculated. For example, the HF wire antenna, the Sabreliner airframe length, and the high-frequency wavelengths are all of comparable magnitude. As a result the entire airframe can be expected to be a part of the HF antenna system. Any considerations of the coupling loss to be expected along the airframe, consequently become intra-antenna system (near-field) considerations. Thus, this technique cannot be applied to HF systems. In fact, there is no known practicable analytic solution to this type of problem.

The expressions given above for circular cylinders and conical-cylinders have been automated. This automated model is used as a subroutine in the overall interference prediction model. Additional details of the program, including the mathematical development of the geometrical considerations involved, are contained in Reference 6.

The input data required for this subroutine are:

a. $Z_i$ = The frame number of the ith antenna. This corresponds to a Z axis dimension in inches.

b. $\phi_i$ = The angle around the airframe of the ith antenna location in degrees, using the top centerline as the zero degree reference.

c. $f_i$ = The operating frequency of the transmitter associated with the ith antenna in MHz.

d. The antenna height in feet from the centroidal axis of the airframe, i.e., the radius of the airframe at the ith antenna.

For those considerations involving the losses between the navigational antennas on the vertical stabilizer and the transmitting antennas along the bottom centerline of the fuselage, the path is considered to be composed of a partial freespace path between the stabilizer antenna and a point on the surface of the fuselage, and then a remaining surface wave path along the fuselage. The point of tangency satisfying the required conditions for the shortest path between the antennas is computed, the characteristics of each portion of the path are determined, and then the total loss is calculated using the same techniques previously described. The expressions used to evaluate these paths are explained in Reference 6.

Logical flow diagrams and a program listing written in the Fortran V language are contained in APPENDIX I.

### Expected Error in $L_p$

Previous measurements have been made to validate predictions made with this technique. A total of 121 measurements were made in a KC-135 aircraft in the UHF (225-400 MHz) portion of the spectrum. The results of the validation effort may be summarized as follows:

1. Of the 121 measurements, only two were considered suspect and omitted from the comparison.
2. The mean error between the predictions and the remaining 119 observations was 0.5 dB and the standard error was 4 dB.
3. The distribution of the errors appears to be normal about a mean of 0 dB with a standard deviation of 4 dB, based on a chi-squared test at a 0.05 significance level. Further details on these data are contained in Reference 6.

**Sabreliner Coupling Loss Predictions**

Since an isotropic radiator does not exist, the path loss between two such antennas cannot be measured. However, an effective coupling loss, which includes the effect of the respective antenna radiation characteristics can be measured.

The effective coupling loss can be calculated from the following equation:

$$C_e = G_{Te} + G_{Re} + P - L_p \qquad (3\text{-}10)$$

where:

$C_e$ = the transmission loss between the transmitting and the receiving antennas in dB.

$G_{Te}, G_{Re}$ = the effective gain relative to an isotropic antenna of the transmitting and receiving antennas in the direction of the ray path between the antennas.

$P$ = the polarization mismatch between the antennas.

$L_p$ = the path loss as previously defined.

Polarization mismatches, P, which can be expected are shown in TABLE 3-3. These values have been used in this analysis for the non-aperture antennas. For the aperture antennas, the values are appropriate only when considering the radiation in the mainbeam of the pattern. When sidelobe or backlobe radiation is being considered, no polarization mismatch is assumed to exist. These correction factors are not currently included in the automated model. They could, however, be included in any antenna gain calculation subroutine which might be developed in the future.

In addition to the parameters discussed above, an additional factor must be considered in connection with the paths between the antennas located in front of the metal nose bulkhead, and the antennas behind the bulkhead. A knife-edge diffraction loss can be expected along these paths due to the obstruction created by the bulkhead. Bullington presents a nomograph which can be used to calculate these losses (See Reference 2, Chapter 33). This nomograph has been automated in equation form and this additional loss factor is automatically included when the transmission path crosses the nose bulkhead.

The equation used is

$$L_K = 10 \log h^2 f/20d \qquad (3\text{-}11)$$

where:

$L_K$ = the knife-edge diffraction loss in dB.

$h$ = the height of the obstruction above the line-of-sight path in feet.

$f$ = the transmitted frequency in megahertz.

$d$ = the distance between the bulkhead and the nearest antenna under consideration in feet.

TABLE 3-3
POLARIZATION MISMATCH LOSSES

| Transmitting Antenna Polarization | Polarization Mismatch Loss (dB Receiving antenna Polarization | | | |
|---|---|---|---|---|
| | Horizontal | Vertical | Linear | Circular |
| Horizontal | 0 | −20 | −3 | −3 |
| Vertical | −20 | 0 | −3 | −3 |
| Linear (45°) | −3 | −3 | 0 | 0 |
| Circular | −3 | −3 | 0 | 0 |

The predicted effective coupling losses in dB between the antennas on the Sabreliner are shown in TABLE 3-4. The antennas are numbered as shown in TABLE 3-2 and may be identified by referring to that table.

## TABLE 3-4
## PREDICTED SABRELINER EFFECTIVE COUPLING LOSSES

| Transmitting Antenna and Nominal Frequency | Effective Coupling Loss in dB Receiving Antenna | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| 1 – 9315 MHz | – | * | 82 | 78 | 93 | 96 | 98 | 100 | 112 | 113 | 129 | 107 | 109 | 110 | 111 |
| 3 – 1025 MHz | 54 | 66 | – | 57 | 55 | 78 | 39 | 40 | 96 | 102 | 84 | 72 | 74 | 70 | 71 |
| 4 – 1090 MHz | 49 | 55 | 57 | – | 34 | 37 | 78 | 78 | 76 | 73 | 70 | 48 | 49 | 70 | 71 |
| 5 – 1025 MHz | 65 | 64 | 55 | 34 | – | 24 | 80 | 79 | 63 | 70 | 67 | 46 | 47 | 85 | 85 |
| 6 – 135 MHz | 40 | 44 | 30 | 19 | 11 | – | 38 | 37 | 39 | 51 | 49 | 27 | 29 | 57 | 57 |
| 6 – 300 MHz | 51 | 55 | 42 | 26 | 18 | – | 54 | 53 | 46 | 59 | 56 | 34 | 36 | 67 | 67 |
| 7 – 1025 MHz | 70 | 76 | 39 | 78 | 80 | 80 | – | 22 | 100 | 103 | 95 | 72 | 70 | 68 | 68 |
| 8 – 135 MHz | 44 | 59 | 23 | 38 | 37 | 37 | 5 | – | 59 | 65 | 60 | 38 | 37 | 49 | 50 |
| 9 – 8800 MHz | 121 | 96 | 135 | 81 | 76 | 72 | 176 | 176 | – | 87 | 105 | 83 | 85 | 131 | 128 |
| 11 – 4300 MHz | 118 | 96 | 110 | 81 | 78 | 77 | 132 | 133 | 101 | 63 | – | 64 | 71 | 114 | 111 |
| 12 – 1025 MHz | 80 | 78 | 72 | 48 | 46 | 45 | 73 | 73 | 64 | 60 | 36 | – | 31 | 80 | 80 |

*Note: These antennas are spaced too closely to enable a prediction.

It is suggested that the accuracy of the predictions be established. A test plan setting forth procedures which can be used to validate these predictions is contained in APPENDIX II. Briefly, the plan contains two methods for obtaining the coupling losses between antennas on the Sabreliner. One of the methods is a directly indicating technique which may be used for the losses at frequencies below 1000 MHz. The second method is a signal substitution technique suitable for use at frequencies above 1000 MHz. Equipment types and layouts are described in the plan and sequential procedures for determining the losses are presented.

### Receiver Rejection, $L_f$

The rejection offered to an undesired emission by a potential victim receiver is calculated by a subroutine known as the Frequency Analysis System (FAS). A simplified explanation, which is largely intuitive, is given herein. This treatment will enable the reader to understand the operation of FAS and will prepare him for the more detailed information, including a purely mathematical presentation, given in Reference 7.

For a given transmitter-receiver pair, FAS synthesizes the receiver response characteristic and the transmitter spectral emission characteristic by a series of line segments which are linear on a logarithmic scale. Each of these synthesized models is normalized to unity at the tuned frequency of the equipment such that the characteristics described are relative to the performance at the tuned frequency. When this synthesis is complete, FAS determines the rejection by integrating over the areas of frequency overlap between the transmitted emission and the receiver response. Two cases are considered. The first case examined involves a calculation of the relative energy transfer to be expected due to the emission sidebands which lie within the passband of the receiver. The second case examined is the expected energy transfer resulting from inadequate receiver selectivity at the frequencies within the fundamental emission bandwidth of the transmitter. These two cases are compared and the worst situation, i.e. the least amount of rejection, is chosen as the appropriate rejection for the given equipment pair.

### Receiver Response Synthesis

The receiver relative response characteristic is synthesized by four line segments, which are linear on a logarithmic scale, and appears as shown in Figure 3-3.

The parameters shown are defined as:

$f_R$ = the tuned frequency of the receiver.

$B_r$ = the intermediate frequency (IF) bandwidth of the receiver.

$N_1$ = the slope of IF selectivity skirt in dB per decade.

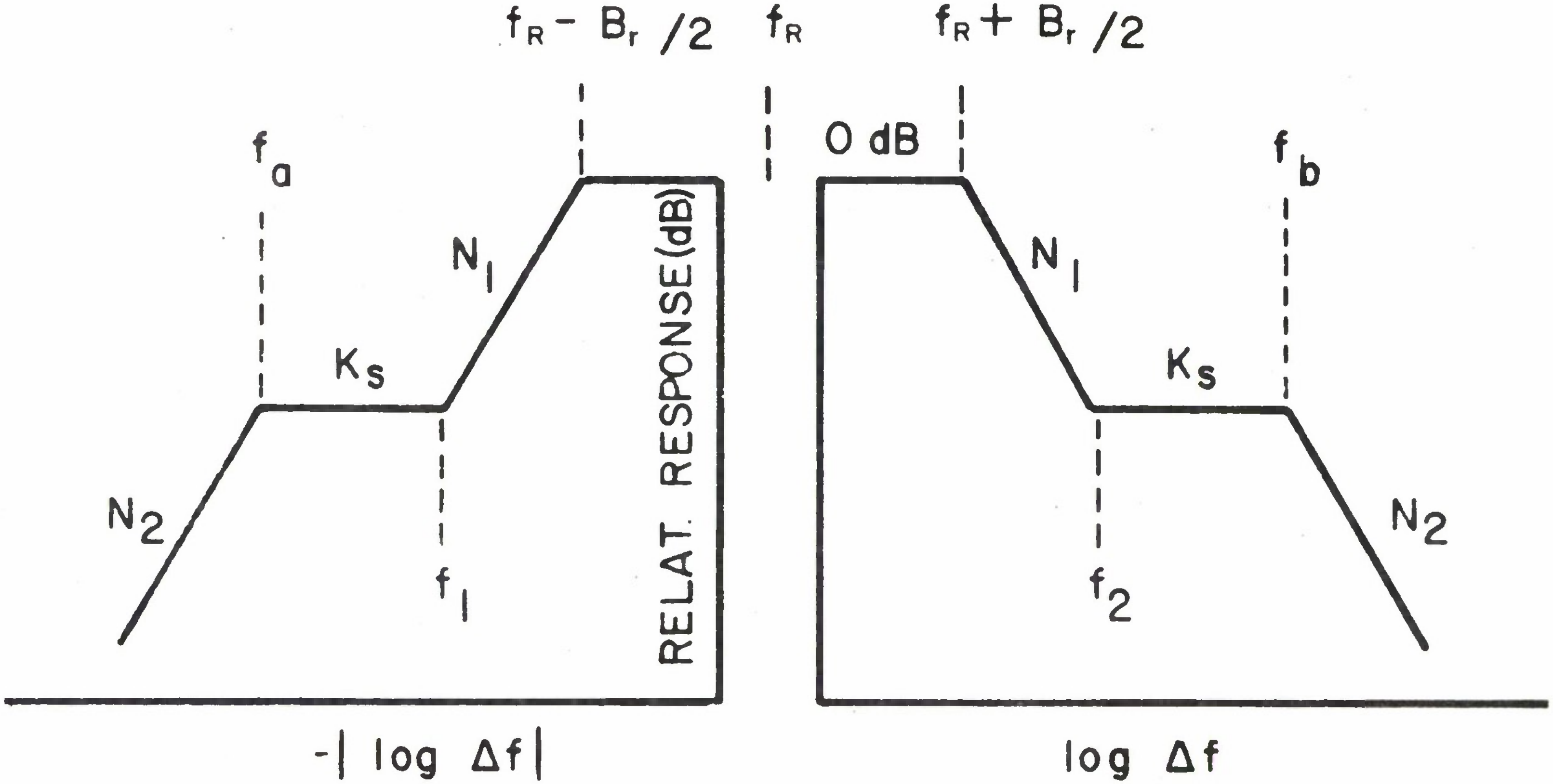


Figure 3-3. Receiver Relative Response Characteristic.

$f_1, f_2$ = the lower and upper frequencies, respectively, where spurious responses must be considered. These frequencies should be selected to coincide with the intersection of the $K_s$ level with the IF selectivity curve.

$k_s$ = the spurious response rejection of the receiver.

$f_a, f_b$ = the lower and upper frequencies, respectively, at which spurious responses need no longer be considered. These frequencies should be selected to coincide with the intersection of the $K_s$ level with the RF circuitry selectivity curve.

$N_2$ = the slope of the RF selectivity skirt in dB per decade.

The response characteristic may be expressed mathematically as:

$$r(f) = 1, \text{ when } \left(f_R - \frac{B_r}{2}\right) < f < \left(f_R + \frac{B_r}{2}\right) \tag{3-12a}$$

$$r(f) = \left(\frac{\frac{B_r}{2}}{f - f_R}\right)^{n_1}, \text{ when } f_1 < f < f_R - \frac{B_r}{2}, \tag{3-12b}$$

$$\text{or } f_2 > f > f_R + \frac{B_r}{2}$$

$$r(f) = k_s, \text{ when } f_a < f < f_1 \tag{3-12c}$$

$$\text{or } f_b > f > f_2$$

$$r(f) = k_s \left(\frac{f_b - f_R}{f - f_R}\right)^{n_2}, \text{ when } f_b < f \tag{3-12d}$$

$$r(f) = k_s \left(\frac{f_a - f_R}{f - f_R}\right)^{n_2}, \text{ when } f < f_a \tag{3-12e}$$

where:

$r(f)$ = the relative response of the receiver at frequency f

Then:

$R(f)$ = the relative response in dB where $R(f) = 10 \log r(f)$, and

$K_s$ = $10 \log k_s$.

$N_1, N_2$ = $10\, n_1$, $10\, n_2$ respectively

Except for $f_1$ and $f_2$, the parameters shown are required inputs for the FAS subroutine. Methods of determining these parameters are explained below.

**Receiver Tuned Frequency, $f_R$**

The tuned frequency of the receiver is obtained from the frequency assignment appropriate to the receiver being considered.

**IF Bandwidth, $B_r$**

The intermediate frequency bandwidth is obtained from the nominal characteristics of the receiver, usually set forth in the manufacturer's data or Technical Manual describing the equipment, or it is obtained from measured data.

**IF Skirt Slope, $N_1$**

This parameter is extracted from the given IF selectivity characteristics. It is the slope of the skirt in dB per decade. For example, the nominal characteristics of a receiver may specify that the IF selectivity of a receiver has a 20 dB bandwidth of $BW_1$ and a 60 dB bandwidth of $BW_2$. Then $n_1$ is obtained from:

$$(60 - 20)\ \text{dB} = 40\ \text{dB} = 10\, n_1 \log \frac{BW_2}{BW_1} \tag{3-13a}$$

and,

$$N_1 = \frac{40}{\log \dfrac{BW_2}{BW_1}} \tag{3-13b}$$

## RF Skirt Slope, $N_2$

The characteristics of the RF circuitry usually must be theoretically synthesized, unless measured data are available. However, measured RF characteristics are normally available only as a result of a special effort intended to study such characteristics. Accordingly, two alternate methods for synthesizing the RF selectivity are presented.

The first method requires information concerning the receiver design, i.e., the number of tuned circuits preceding the first mixer in a receiver. This information can be obtained by examination of the circuit diagrams included in the technical manual describing the equipment. When the number of tuned circuits is known, the relative response of the circuitry can be calculated from the following equation:

$$R_{RF} = 20 \log \left[ 1 + \left( \frac{2 \left| f - f_R \right|}{f_R} Q_s \right)^2 \right]^{-n/2} \qquad (3\text{-}14a)$$

or

$$R_{RF} = -10n \log \left[ 1 + \left( \frac{2 \left| f - f_R \right|}{f_R} Q_s \right)^2 \right] \qquad (3\text{-}14b)$$

where:

$R_{RF}$ = the response in dB relative to the response at the tuned frequency of the receiver.

$n$ = the number of tuned circuits preceding the first mixer.

$f$ = the frequency at which the relative response is required.

$f_R$ = the tuned frequency of the receiver.

$Q_s$ = the selectivity factor of each tuned stage as defined by:

$$Q_s = \frac{f_R}{2 \left| f - f_R \right|_{3dB}}, \qquad (3\text{-}15)$$

where

$2\,|f-f_R|_{3dB}$ = the 3 dB bandwidth of the stage.

The parameter, $Q_s$ is not generally available and must be estimated. An estimated $Q_s$ of 50 yields sufficiently conservative results for most analyses.

The solution of equation (3-14) as a function of frequency will yield the relative selectivity of the RF circuitry of the receiver. The parameter, $n_2$ is equivalent to 2n, where n is the number of tuned circuits or

$$N_2 = 10\,n_2 = 20\,n$$

In certain cases, the number of tuned circuits preceding the mixer is unknown but the RF 3 dB bandwidth is specified along with the image rejection. When these parameters are given, an alternative method for estimating the RF characteristics can be used.

The image frequency of a receiver is separated from the tuned frequency by twice the intermediate frequency. If an "image bandwidth" is defined as equal to four times the intermediate frequency, i.e., twice the image frequency separation from the tuned frequency, then the parameter $N_2$ can be approximated by:

$$K_I - 3\text{dB} \cong 10\,n_2 \log \frac{BW_I}{BW_{3dB}} \quad \text{or,} \tag{3-16a}$$

$$N_{2a} \cong \frac{K_I - 3\text{ dB}}{\log \dfrac{BW_I}{BW_{3\text{ dB}}},} \tag{3-16b}$$

where:

$N_{2a}$ = the approximate value of $N_2$

$K_I$ = the image rejection in dB.

$BW_I$ = the "image bandwidth" defined above (note that this bandwidth is a mathematical device and not a physical reality).

$BW_{3dB}$ = the specified 3dB RF bandwidth of the receiver.

It should be noted that, since the universal resonance curve, when plotted on a logarithmic scale, is rounded rather than linear in the vicinity of the 3dB bandwidth, the value of $N_{2a}$ obtained from equation (3-16) will be slightly larger than is appropriate. Therefore, this value should be rounded off to the nearest multiple of 20 which is less than that value. Thus, $N_2 = N_{2a}$ rounded down to the nearest multiple of 20. When this value of $N_2$ is determined, then n, the number of stages, is obtained by dividing by 20. A corresponding value of $Q_s$ for the RF circuitry can then be calculated by:

$$Q_s = Qo[\,2^{1/n} - 1]^{1/2} \qquad (3\text{-}17)$$

where:

$Q_s$ = the effective selectivity factor for each tuned circuit preceding the mixer.

$Q_o$ = the overall selectivity factor for the n tuned circuits.

n = the number of tuned circuits as determined above.

The computation of the two parameters, $Q_s$ and n, results in values which can be used in equation (3-14) above to estimate the RF selectivity characteristics of the receiver.

If neither of these alternatives is feasible due to a lack of information, then a conservative value of 20 should be used for $N_2$. This will result in a worst case prediction of the relative response characteristic of the receiver in this region of frequencies.

**Spurious Response Rejection, $K_s$**

The minimum spurious response rejection is usually specified in the nominal characteristics of the receiver. If not, a worst case rejection level can be estimated in the following manner. Spurious responses arise in a superhetrodyne receiver when a high level interfering signal combines in the mixer circuitry and a product at or near the intermediate frequency of the receiver is generated. In general, the most sensitive of these responses arise due to the mixing of the incoming signal and the first local oscillator in the first mixer stage. The frequencies at which the interfering signal can excite these responses is given by:

$$f_{sp} = \frac{pf_{lo} \pm f_{IF}}{q} \qquad (3\text{-}18)$$

where:

$f_{sp}$ = the frequency of the incoming interfering signal.

$f_{lo}$ = the injection frequency of the local oscillator.

$f_{IF}$ = the intermediate frequency of the receiver.

$p$ = the harmonic of the local oscillator involved in the mix.

$q$ = the harmonic of the incoming signal involved in the mix.

The fact that the sign preceding $f_{IF}$ in equation (3-18) can take on either sense (±) indicates that for a given p,q combination, a pair of responses can be predicted, one for the negative sense and one for the positive sense. In a superheterodyne receiver, the local oscillator frequency, $f_{lo}$, is related to the tuned frequency, $f_R$ as follows:

$$f_{lo} = f_R \pm f_{IF} \, , \qquad (3\text{-}19)$$

where the positive sense is appropriate when the oscillator frequency is above the tuned frequency and the negative sense is appropriate when the reverse situation obtains.

The combination of equations (3-19) with (3-18) yields two sets of relationships:

$$f_{sp} = \left.\begin{array}{l} \dfrac{pf_R}{q} + \dfrac{(p+1)\ f_{IF}}{q} \\ \text{and} \\ \dfrac{pf_R}{q} + \dfrac{(p-1)\ f_{IF}}{q} \end{array}\right\} \text{when } f_{lo} > f_R \qquad (3\text{-}20a)$$

and:

$$f_{sp} = \left.\begin{array}{l} \dfrac{pf_R}{q} - \dfrac{(p+1)\ f_{IF}}{q} \\ \text{and} \\ \dfrac{pf_R}{q} - \dfrac{(p-1)\ f_{IF}}{q} \end{array}\right\} \text{when } f_R > f_{lo} \qquad (3\text{-}20b)$$

These expresssions enable a determination of the frequencies at which an incoming signal can result in the most sensitive spurious responses. Note that when p=q=1, the pair of responses which result are the receiver response to its tuned frequency and the response to its image frequency. The relative rejection at the tuned frequency is zero and, from the previous discussion, it is known that the relative rejection at the image frequency is merely the RF rejection at that frequency.

The relative spurious rejection for any other p,q combination is the product of the RF rejection at the incoming frequency, $f_{sp}$, and the relative mixer conversion loss for the p,q combination being studied. This can be expressed logarithmically as:

$$K_s = R_{RF}\Big|_{f = fsp} + \mu_c\Big|_{p,q} \qquad (3\text{-}21)$$

where:

$K_s$ = the relative spurious rejection in dB.

$R_{RF}$ = the relative rejection of the RF circuits to $f_{sp}$ in dB.

$\mu_c$ = the mixer conversion loss to the actual p,q combination relative to the mixer conversion loss to the p = q = 1 combination.

In a previous ECAC measurement effort, representative values of the relative mixer conversion losses for a transistor mixer were established. These values are shown in TABLE 3-5.

TABLE 3-5
RELATIVE TRANSISTOR MIXER CONVERSION LOSS IN dB

| P \ Q | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | 0 | −65 | −76 | −84 | −83 |
| 2 | −13 | −58 | −77 | −83 | −83 |
| 3 | −13 | −65 | −77 | −81 | −82 |
| 4 | −20 | −62 | −81 | −81 | −82 |
| 5 | −22 | −62 | −78 | −84 | −82 |

The relative spurious rejection level obtained with equation (3-21) for the most susceptible response, excluding the image response, is the value which should be used as an input to the program. The image rejection is also a required input but the image response is treated as a special case when this phenomenon is a potential problem. When this latter situation does arise, the receiver is synthesized around the image frequency in an identical manner to the synthesis about the tuned frequency, except that the relative threshold is reduced by the input image rejection.

### Spurious Response Limit Frequencies, $f_a$,$f_b$

As stated previously, these frequencies are determined from the point where the $K_s$ level intersects the RF selectivity curve. It should be noted, however, that $f_a$ and $f_b$ are discrete frequencies, rather than frequency separations. Since the RF selectivity is usually specified in terms of response versus frequency separation, the intersection point is more readily obtained in terms of a frequency separation. It is necessary, therefore, to add this separation to (or subtract it from) the receiver tuned frequency to obtain the appropriate values of $f_a$ and $f_b$. As will be seen later, this situation has ramifications involving different levels of refinement in the analysis.

### Transmitter Spectral Emission Synthesis

The synthesis of the envelope of the spectral characteristics of the transmitted emission is synthesized by three line segments which are linear on a logarithmic scale as shown in Figure 3-4.

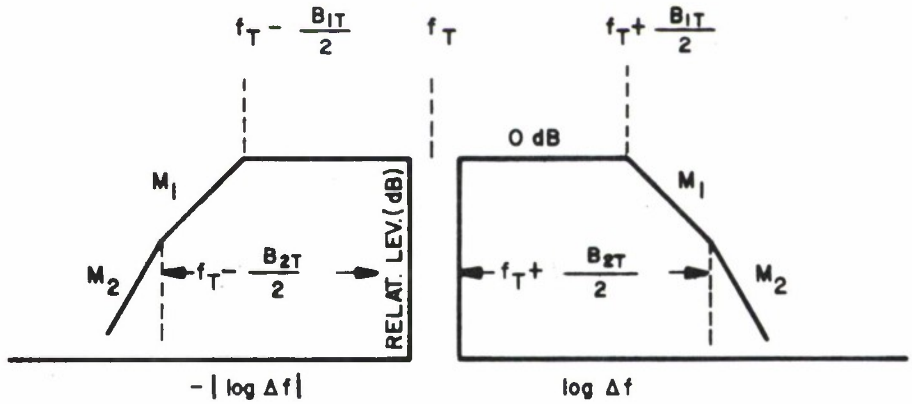


Figure 3-4. Relative Spectral Emission Envelope Characteristic.

The parameters shown are identified as:

$f_T$ = the tuned frequency of the transmitter.

$B_{1T}$ = the 3 dB emission bandwidth.

$M_1$ = 10 $m_l$ the slope of the emission envelope at frequencies adjacent to the 3 dB bandwidth in dB/decade.

$B_{2T}$ = the emission bandwidth at which the envelope shows a different fall-off characteristic.

$M_2$ = 10 $m_2$ = slope of the emission envelope at frequencies greatly separated from the tuned frequency in dB/decade.

The emission characteristic may be expressed mathematically as:

$$t(f) = 1 \text{ when } \left(f_T - \frac{B_{1T}}{2}\right) < f < \left(f_T + \frac{B_{1T}}{2}\right) \tag{3-22a}$$

$$t(f) = \left(\frac{\frac{B_{1T}}{2}}{f - f_T}\right)^{m_1} \tag{3-22b}$$

$$\text{when } \left(f_T + \frac{B_{1T}}{2}\right) < f < \left(f_T + \frac{B_{2T}}{2}\right)$$

$$\text{or } \left(f_T - \frac{B_{2T}}{2}\right) < f < \left(f_T - \frac{B_{1T}}{2}\right)$$

$$t(f) = \left(\frac{B_{1T}}{B_{2T}}\right)^{m_1} \times \left(\frac{\frac{B_{2T}}{2}}{f - f_T}\right)^{m_2} \tag{3-22c}$$

$$\text{when } \left(f_T + \frac{B_{2T}}{2}\right) < f$$

$$\text{or } f < \left(f_T - \frac{B_{2T}}{2}\right)$$

where:

$t(f)$ = the relative level of the spectral emission envelope at frequency f; and,

$T(f)$ = 10 log t(f), the relative level in decibels.

Each of these parameters must be specified as inputs to the FAS subroutine and may be determined in the following manner.

**Communications Transmitters**

The required inputs to enable synthesis of the spectral envelope of communications transmitters may be set forth into two categories, AM and FM cases. The inputs for the AM transmitters are:

$B_{1T}$ = $2\ f_m$, where $f_m$ is the highest modulation frequency.

$M_1$ = 80 dB per decade.

$B_{2T}$ = $20\ f_m$.

$M_2$ = 20 dB per decade.

The inputs for the FM transmitters are:

$B_{1T}$ = $2\ f_d$ where $f_d$ is the rated frequency deviation.

$M_1$ = 80 dB per decade.

$B_{2T}$ = $20\ f_d$.

$M_2$ = 20 dB per decade.

The specification of 20 dB/decade for $M_2$ represents the expected minimum fall-off characteristic of the noise sidebands of these transmitters. If an external RF filter is used in conjunction with the transmitter, the fall-off characteristic of the filter should be added to $M_2$.

**Pulsed Transmitters**

The required inputs for pulsed transmitters can also be categorized into two cases, i.e., pulsed transmitters without frequency modulation during the pulse interval (P0 emission), and pulsed transmitters with frequency modulation during the pulse interval, i.e. "chirped"

pulses (P9 emission).

For P0 emissions, the spectral envelope can be found using the methods described in Reference 8. The results are:

$B_{1T}$ = $1.28/(2\tau + t_r + t_f)$

$M_1$ = 20 dB/decade for trapezoidal pulses and 40 dB/decade for shaped pulses.

$B_{2T}$ = $0.32\left(\frac{1}{t_r} + \frac{1}{t_f}\right)$

$M_2$ = 40 dB/decade,

where:

$\tau$ = the pulse width between one-half amplitude points.

$t_r$ = the time required for the pulse to rise from its 10 percent amplitude point to its 90 percent amplitude point, i.e., the pulse rise time.

$t_f$ = the time required for the pulse to drop from its 90 percent level to its 10 percent level, i.e., the pulse fall time.

The parameters, $\tau$, $t_r$, and $t_f$ can be obtained from the nominal characteristics of the equipment.

The determination of the envelope parameters of a chirped pulse can be quite complex (See Reference 9), and the resulting emission spectral envelope for such a pulse is not always amenable to a three line segment synthesis technique. However, for most practical cases, the required inputs can be determined as:

$B_{1T}$ = $f_d\left[1 - \left(\frac{2}{D}\right)^{1/2}\right]$

where:

$f_d$ = the total frequency deviation during the pulse.

D = the Dispersion ratio = $\tau f_d$, where $\tau$ is the total duration of the pulse.

$B_{2T}$ = $f_d \left[1 + \left(\frac{2}{D}\right)^{1/2}\right]$

and:

$M_1$ = the slope of the line in dB/decade which joins the points $\frac{B_{1T}}{2}$ and $\frac{B_{2T}}{2}$ when those points are plotted on a logarithmic scale.

$M_2$ = 40 dB/decade.

**Harmonic Emissions**

In addition to synthesizing the envelope of the spectral characteristics of the fundamental emission of the transmitter, the model also automatically synthesizes the spectral envelopes of the transmitted harmonics up to a maximum of the ninth harmonic. In doing so, the subroutine assumes that the spectral characteristics of each harmonic are identical to that of the fundamental except that the reference point is reduced by a level in dB equal to the attenuation specified as appropriate to the harmonic. The attenuation level for each harmonic to be considered is a required input parameter.

**Rejection Calculation**

After the receiver response and spectral emission characteristics have been synthesized, and each has been normalized to the level appropriate at the tuned frequency of the equipment, the expected rejection offered by the receiver to the undesired emission can be calculated using only frequency relationships. The development of this concept is given below.

The spectral power density of an emission can be approximated by:

$$P_D = \frac{P_T}{B_{1T}} \tag{3-23}$$

where:

$P_D$ = the spectral density in watts/Hz.

$P_T$ = the average transmitter power in watts.

$B_{1T}$ = the 3 dB emission bandwidth in Hz.

Thus $P_D$ represents an approximation to the average energy content in the emission. However, the receiver can only intercept that energy for a period of time equal to its "response time". The "response time", $\tau_R$, of a receiver can be considered to be the inverse of its 3 dB bandwidth. Accordingly, the maximum power transfer between a transmitter and receiver can be calculated by:

$$P_r = \frac{P_D}{\tau_R} = \frac{P_T}{B_{1T}\,(\tau_R)} = P_T \frac{B_R}{B_{1T}} \qquad (3\text{-}24)$$

where:

$P_r$ = the average received power in watts.

$B_R$ = the 3 dB bandwidth of the receiver.

The receiver rejection, $I_f$, is the ratio of the received power to the transmitted power:

$$I_f = \frac{P_r}{P_T} = \frac{B_R}{B_{1T}} \quad \text{or in logarithmic terms,} \qquad (3\text{-}25)$$

$$L_f = 10 \log I_f = 10 \log \frac{B_R}{B_{1T}}$$

This maximum power transfer occurs when the transmitter and receiver are tuned to the same frequency. Therefore, a co-channel rejection factor $(I_f)_{co}$ can be defined as:

$$(I_f)_{co} = \frac{B_R}{B_{1T}}, \quad \text{when } B_{1T} > B_R \qquad (3\text{-}26)$$

and

$$1, \quad \text{when } B_{1T} \leqslant B_R$$

The reason for the two cases is evident when it is remembered that a receiver cannot receive more power than is transmitted.

It should be noted, however, that the co-channel rejection factor in equation (3-26) has been defined in terms of average power. When the undesired emitter is a pulsed transmitter, the peak received power is usually of more interest than the average received power. Thus for a pulsed transmitter:

$$(P_T)_{avg} = (P_T)_{pk}\ \tau\ (PRF) \qquad (3\text{-}27)$$

where:

$(P_T)_{avg}$ = the average power in watts.

$(P_T)_{pk}$ = the peak power in watts.

$\tau$ = the pulse duration in seconds.

PRF = the pulse repetition frequency in hertz.

If equation (3-27) is combined with equation (3-24) then:

$$(P_R)_{avg} = (P_T)_{pk}\ \tau\ (PRF)\ \frac{B_R}{B_{1T}} \qquad (3\text{-}28)$$

However, in a pulsed transmitter, $\tau \simeq \frac{1}{B_{1T}}$ , and the average received power $(P_R)_{avg}$ is related to the peak received power, $(P_R)_{pk}$, by:

$$(P_R)_{avg} = (P_R)_{pk}\ \tau_R\ PRF \qquad (3\text{-}29)$$

where:

$\tau_R$ = the response time of the receiver, which is approximately $\frac{1}{B_R}$.

Thus, combining equation (3-29) with equation (3-28) and defining a co-channel rejection factor for pulsed emissions, it is seen that:

$$(l_f)_{co} = \left(\frac{B_R}{B_{1T}}\right)^2, \quad \text{when } B_{1T} > B_r \qquad (3\text{-}30)$$
$$\text{and}$$
$$1 \text{ when } B_{1T} \leqslant B_r,$$

for considerations involving the peak power transfer due to a pulsed transmitter.

Since the co-channel rejection has been determined, the total rejection, $L_f$, at any frequency can be calculated by:

$$L_f = (L_f)_{co} + R(f_T), \tag{3-31}$$

for considerations involving the power transfer resulting the fundamental emission of the transmitter due to inadequate receiver selectivity; and

$$L_f = (L_f)_{co} + T(f_R), \tag{3-32}$$

for considerations involving the power transfer resulting from the emission sidebands which occur within the receiver passband, where:

$R(f_T)$ = the relative response of the receiver at frequency $f_T$.

$T(f_R)$ = the relative emission level of the transmitter at frequency $f_R$.

The FAS subroutine essentially calculates the value of $L_f$ for each of the situations given above, compares the two values, and selects the lowest of the values obtained for use in equation (3-5). However, since both the relative response characteristic of the receiver and the relative emission levels of the transmitter can vary over a range of frequencies, the computation is made using integration techniques.

Further details on the subroutine, including a rigorous mathematical description of the calculation techniques, are contained in Reference 7. A logical flow diagram and a program listing written in the Fortran V language are contained in APPENDIX III.

### Degradation Thresholds, $(S/I)_T$

The input signal-to-interference ratio at which operational degradation begins to occur in a receiver is defined as the degradation threshold and is identified by the symbol $(S/I)_T$. This threshold is a required input parameter for each receiver under consideration.

### Communications Receivers

The required signal-to-interference ratios for the receivers used for voice communications were obtained from Reference 10, which contains the results of subjective listener tests made to establish the intelligibility of voice transmissions as a function of the input signal-to-interference ratios. The tests were conducted using ATC specialists as subjects and normal ATC messages as well as modified rhyme test (MRT) words as the test

messages. The interfering signals used were FM and AM signals. The pertinent results are summarized in TABLE 3-6.

TABLE 3-6
RESULTS OF VOICE INTELLIGIBILITY TESTS

| | Worst Case Input $(S/I)_T$ for 100 % Intelligibility (dB) | |
|---|---|---|
| Type of Message | FM Desired Signal | AM Desired Signal |
| ATC | 9 | 0 |
| MRT | 15 | 10 |

The levels shown for the ATC message thresholds are considered appropriate for trained commercial pilots while the MRT message thresholds are applicable to inexperienced pilots who are not necessarily familiar with ATC messages.

**Navigation Receivers**

The only documentation describing the threshold appropriate to the VOR/ILS receivers was found in Reference 11, which states that an $(S/I)_T$ of 20 dB is required to prevent degradation in these receivers.

**DME, TACAN Receivers**

Reference 11 states that a signal-to-interference ratio of 8 dB is required to insure satisfactory operation of this type of receiver. However, measurements conducted on a representative airborne TACAN receiver (See Reference 12), indicated that a $(S/I)_T$ of 10 dB is required in the presence of a CW interfering signal and a $(S/I)_T$ of −10 dB is required in the presence of an interfering IFF pulse. During these tests, the TACAN receiver was being operated in an air-to-air mode on 1090 MHz and an IFF reply code of 1311 was used as the interfering signal. No degradation due to this coded reply was observed when the TACAN receiver was operated within the 962-1024 MHz or 1151-1213 MHz frequency ranges.

### ATC Transponder Receiver

Measurements reported in Reference 13 indicate that the threshold of degradation to be expected for the ATC transponders used on commercial airlines is 10 dB, if the interfering signal is a CW emission and 0 dB, if the interfering signal is a pulsed emission. Although the measurements were not conducted on the type of transponder installed on the Sabreliner, the similarities in the design of the two units and the interference rejection features of each indicate that the performance of the Sabreliner transponder can be expected to be equivalent to, if not superior to, the performance of the tested transponder in the presence of interference.

### Radar Receivers

No information has been found which specifies the degradation thresholds for the receivers employed in the weather radar, the doppler radar, and the altimeter systems. Therefore, a conservative value of 10 dB has been assumed for these analyses.

### Receiver Sensitivity, $R_S$

The sensitivity, or performance threshold, of each receiver to be considered is a required input parameter for the analyses. It can be obtained from the nominal characteristics describing the equipment or from measured data.

## SUMMARY

This section has described the model developed to predict potential interference interactions between equipments on an airplane. The prediction model has been developed and automated as an equation relating the expected effective interfering power at the input of a receiver to the effective power which would result in degradation. This approach provides inherent flexibility within the model in that each parameter in the expression can be replaced with a subroutine and individual subroutines can be replaced. Thus, the model is amenable to extension or expansion into a larger model capable of predicting inter-aircraft and aircraft-to-ground environment interactions as well as the intra-aircraft analysis for which it was developed.

The model is not sensitive to a particular airframe or to particular equipment types. The airframe coupling model is valid for all practical airframes. The ability to evaluate the interactions in different types of equipments is inherent due to the requirement that the individual equipment performance models are established external to the prediction model and

used as input parameters. At the present time, these performance models are developed manually and the methods used to accomplish this effort have been described herein. This phase of the problem can also be substantially automated through the development of an equipment synthesis pre-processor.

# SECTION 4

# PROGRAM UTILIZATION

This section presents information related to the use of the program for interference analysis. The input and output data are described, and a discussion of the procedures followed by the program is presented. Finally, the methods necessary for more refined analyses are explained.

## Input Data

The program requires input data on standard 80 column automatic data processing punch cards. The cards are: one general parameter card; two data cards for each transmitter, and two data cards for each receiver. Three card field formats are used to present the data; alpha-numeric characters, integral characters, and floating point decimal characters.

### General Parameter Card

The format of the general parameter card is shown in TABLE 4-1.

TABLE 4-1
GENERAL PARAMETER INPUT CARD FORMAT

| Columns | Description | Field Format |
|---|---|---|
| 1-2 | Total Number of Transmitters (50 maximum) | Integer |
| 6-7 | Total Number of Receivers (50 maximum) | Integer |
| 11-17 | Frame Number of Nose Bulkhead | Floating Point |
| 21-27 | Radius of Nose Bulkhead in feet | Floating Point |

The first two items are self-explanatory. These numbers enable the computer to determine how many possible interactions it must examine before the problem is completed.

The frame number and radius of the bulkhead are used to enable a calculation of the expected knife-edge losses along those paths which traverse the obstruction created by the bulkhead as explained in Section 3.

## Transmitter Data Cards

The formats of the two transmitter data cards are shown in TABLE 4-2.

### TABLE 4-2
### TRANSMITTER DATA CARD FORMATS

Card 1

| Columns | Description | Field Format |
|---|---|---|
| 1-2 | Antenna Number | Alpha-Numeric |
| 3-12 | Descriptive Code | Alpha-Numeric |
| 14-21 | Lower Operating Frequency (MHz) | Floating Point |
| 23-30 | Upper Operating Frequency (MHz) | " |
| 32-37 | Primary Bandwidth (kHz) | " |
| 39-44 | Secondary Bandwidth (kHz) | " |
| 46-49 | First Spectrum Slope Falloff (dB/decade) | " |
| 51-54 | Second Spectrum Slope Falloff (dB/decade) | " |
| 56-58 | Transmitter Power (dBm) | " |
| 60-63 | Antenna Gain (dBi) | " |
| 65-67 | Modulation Type | Alpha-Numeric |
| 69 | Pulse Compression Indicator (C=Chirped, otherwise blank) | " |
| 71-74 | Pulsewidth ($\mu$s) | Floating Point |
| 76-79 | Pulse Rise Time ($\mu$s) | " |

Card 2

| Columns | Description | Field Format |
|---|---|---|
| 1-6 | Lower Filter Limit (MHz) | Floating Point |
| 8-13 | Upper Filter Limit (MHz) | " |
| 15-20 | Frame Number of Antenna | " |
| 22-26 | Antenna Height in Feet | " |
| 28-31 | Antenna Angle (degrees) | " |
| 33 | Raised Antenna Indicator (0=No; 1=Yes) | Integer |
| 35 | Number of Harmonics to be Examined (1-9) | Integer |
| 37-40 | Suppression Level of Second Harmonic (dB) | Floating Point |

TABLE 4-2 (Cont.)

Card 2

| Columns | Description | Field Format |
|---|---|---|
| 42-45 | Suppression Level of Third Harmonic (dB) | Floating Point |
| 47-50 | Suppression of Fourth Harmonic (dB) | " |
| 52-55 | Suppression Level of Fifth Harmonic (dB) | " |
| 57-70 | Suppression Level of Sixth Harmonic (dB) | " |
| 62-65 | Suppression Level of Seventh Harmonic (dB) | " |
| 67-70 | Suppression Level of Eighth Harmonic (dB) | " |
| 72-75 | Suppression Level of Ninth Harmonic (dB) | " |

The antenna number is used as an identifier for the transmitter and its associated antenna. These two columns are used by the program to identify transmitter-receiver common equipment. It is intended, therefore, that these columns be used as an antenna identifier so that when the program selects the receiver using the same antenna for examination, it realizes that a transceiver is involved and does no calculation for that particular equipment pair. Columns 3-12 can be used as any description code associated with the transmitter. As an illustration, consider the following pair of descriptions:

```
11  UHF  XMTR
11  UHF  RCVR
```

As is evident, the two descriptions are intended to identify a UHF transceiver connected to antenna number 11. As the program examined transmitter-receiver pairs for possible interactions, it would recognize these descriptions as components of the same system because the characters in the first two columns are identical. The program would, accordingly, skip this calculation. It is important, therefore, that the antenna associated with any transceiver be given the same number to prevent an unfounded determination of potential interference.

The next two items, the lower and upper operating frequencies, are used to describe a transmitter capable of being tuned over a range of operating frequencies. When this situation occurs, the program synthesizes the spectral characteristics of the transmitter and then examines the potential interference from the transmitter over its entire range of operating frequencies. When a specific operating frequency is appropriate, these two fields should be completed identically with the known operating frequency. When more than one specific frequency must be examined, but a continuous tuning range is inappropriate, a separate set of

transmitter data cards should be included for each operating frequency.

The next four items, the bandwidths and slope characteristics, are explained in Section 3, where the primary bandwidth is $B_1T$, the secondary bandwidth is $B_2T$, and the first and second slope fall-offs are $M_1$ and $M_2$, respectively. The transmitter power in dBm and the antenna gain in dBi were discussed previously.

The required modulation indicators are the standard designators; A3, F3, P0, P9, etc., and are used to enable the program to calculate the expected peak interfering signal when appropriate. The important designators are the pulse designators as explained in Section 3.

The pulse compression indicator column is left blank unless the transmitter uses frequency modulation during the pulse duration. If the transmitter is chirped, the letter "C" is used in the column.

The pulse characteristics, width and rise time, are self-explanatory.

The lower and upper filter limits are used to truncate the spectral energy of the transmitted emissions. When these values are submitted, the program assumes that the filter has an infinite slope outside the region described by the limits. The primary application for these data is to describe waveguide cut-off phenomena.

The geometric parameters describing the antenna placement on the airframe are used to determine the coupling losses. The frame number, which corresponds to a Z-axis coordinate in inches, and the antenna angle, which corresponds to a $\varphi$ coordinate in degrees using the upper fuselage centerline as a reference, enable the ray path length and curvature loss factor to be determined.

The antenna height in feet corresponds to the distance of the antenna from the centroidal axis of the airframe. In the case of an antenna which is surface mounted on the fuselage, this parameter represents the radius of the airframe at the corresponding frame number.

The raised antenna indicator is used to identify those antennas which are not surface mounted on the fuselage. For example, the VOR/ILS antennas on the vertical stabilizer are raised antennas. This enables the program to determine the free-space portion of the transmission path between a surface mounted antenna and a raised antenna. In doing so, the model assumes that the airframe is cylindrical with a radius equal to the height of the surface mounted antenna.

The user may select the number of harmonic emissions to be examined during the analysis. If the number 1 is specified, only the fundamental emission spectrum is modeled. If the number is greater than one, then each harmonic is synthesized in a manner identical to the fundamental emission, except that the beginning level is suppressed by the amount specified by the user for each harmonic in the fields designated above.

**Receiver Data Cards**

The formats of the two receiver data cards are shown in TABLE 4-3.

TABLE 4-3
RECEIVER DATA CARD FORMATS

Card 1

| Columns | Description | Field Format |
|---|---|---|
| 1-2 | Antenna Number | Alpha-Numeric |
| 3-12 | Descriptive Code | Alpha-Numeric |
| 14-21 | Lower Operating Frequency (MHz) | Floating Point |
| 23-30 | Upper Operating Frequency (MHz) | " |
| 32-37 | IF Bandwidth (kHz) | " |
| 39-42 | IF Frequency (MHz) | " |
| 44-47 | IF Selectivity Slope (dB/decade) | " |
| 49-52 | RF Selectivity Slope (dB/decade) | " |
| 54-56 | Image Rejection (dB) | " |
| 58-60 | Spurious Response Rejection (dB) | " |
| 62-69 | Lower Spurious Response Limit (MHz) | " |
| 71-78 | Upper Spurious Response Limit (MHz) | " |
| 80 | Local Oscillator position (A=above; B=Below) | Alpha-Numeric |

Card 2

| Columns | Description | Field Format |
|---|---|---|
| 1-6 | Frame number of antenna | Floating Point |
| 8-12 | Antenna Height in Feet | " |
| 14-17 | Antenna Angle in degrees | " |
| 19 | Raised Antenna Indicator (0=No; 1=Yes) | Integer |
| 21-25 | Receiver Sensitivity (dBm) | Floating Point |
| 27-30 | Antenna Gain (dBi) | " |
| 32-35 | Degradation Threshold (S/I) ratio (dB) | " |

Many of the items in the receiver card fields are either identical to or analogous to the items contained in the transmitter card fields and, accordingly, need no further explanation. However, a discussion of the treatment of the spurious responses will be given.

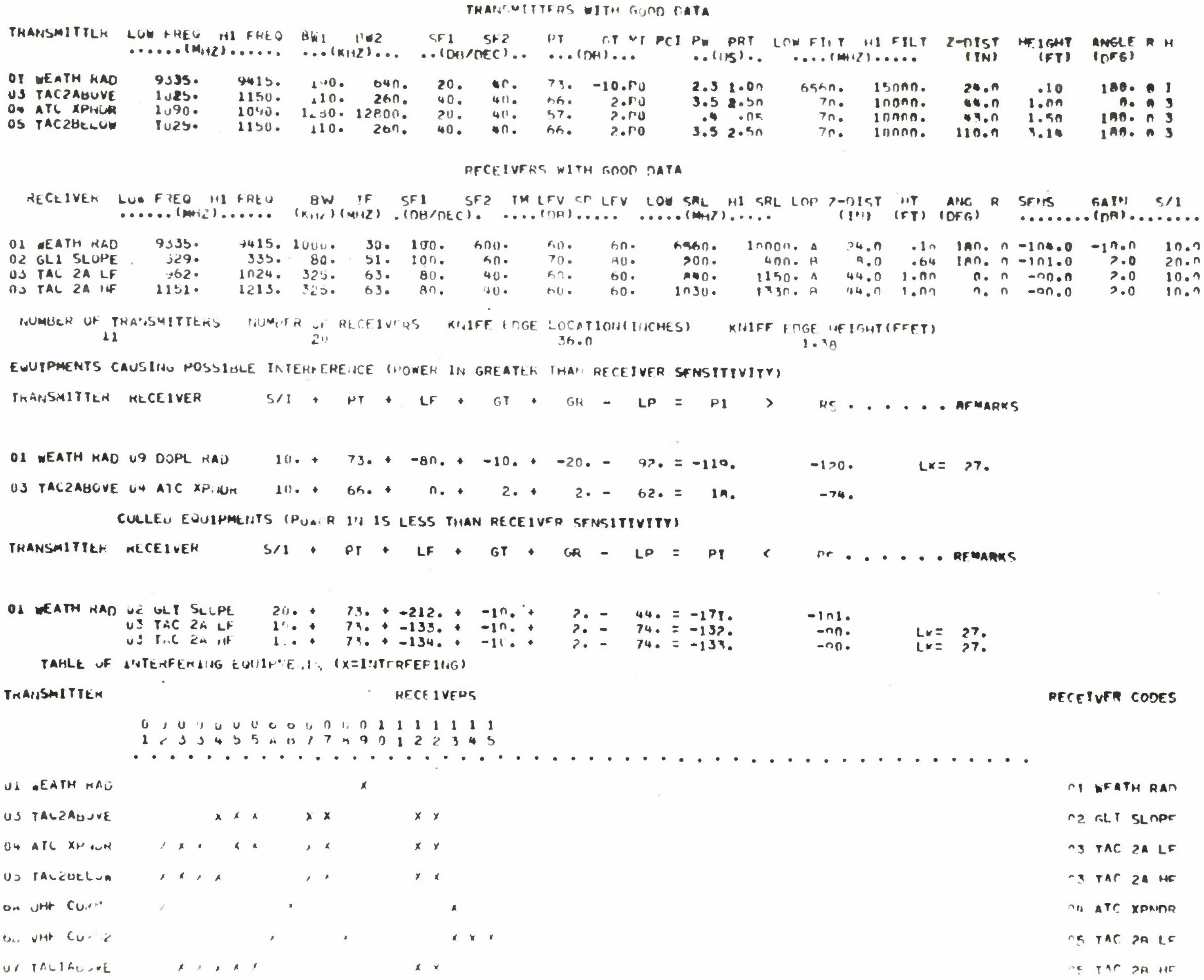
The amplitude characteristic of the image response of the receiver is synthesized in a manner identical to the fundamental response characteristic except that the designated image rejection is used to weight this characteristic. The frequency range of consideration for the image response depends on whether the local oscillator injection frequency is higher or lower than the receiver tuned frequency (See Equation 3-19). In some receivers, the injection frequency can be higher or lower, depending on the segment of its operating range in which the receiver is tuned. For example, the intermediate frequency of the TACAN receivers is 63 MHz. The local oscillator injection signal is derived from the associated transmitter signal. When the receiver operates between 962-1024 MHz, the local oscillator frequency lies above the tuned frequency. When the receiver is tuned between 1151 - 1213 MHz, the oscillator frequency lies below the tuned frequency.

When this situation arises, the receiver should be treated as two separate receivers, one for each portion of its operating band.

As mentioned in Section 3, the frequency limits for consideration of spurious responses are specified as discrete frequencies rather than difference frequencies from the receiver tuned frequency. In a simplified first level analysis, these limits should be chosen to encompass the expected range of spurious responses over the entire operating range of the receiver. For a more refined analysis involving specific operating frequencies, only the frequency limits appropriate to those operating frequencies should be specified. Note that the specification of the spurious response frequency limits in terms of discrete frequencies allows these limits to be assymetrical about the tuned frequency. Examination of Equations (3-20a and3-20b) shows that the most sensitive spurious responses usually are found at frequencies below the tuned frequency when the local oscillator injection frequency lies below the tuned frequency and are found at frequencies above the tuned frequency when the converse is true. Thus, the specification of the limits of the spurious response frequencies in this manner provides a simple, yet flexible, method for enabling different levels of refinement in the analysis.

**Output Formats**

The output of the computer program contains a listing of the input data and the result of the analyses. A partial output listing is shown in Figure 4-1. Note that the listing of the input data for the transmitters and receivers is presented in the exact order required on the input cards previously discussed.



```
                                                  TRANSMITTERS WITH GOOD DATA

TRANSMITTER  LOW FREQ  HI FREQ  BW1   BW2     SF1   SF2     PT     GT MT PCI PW  PRT   LOW FILT  HI FILT  Z-DIST  HEIGHT  ANGLE R H
             ......(MHZ)......  ...(KHZ)...  ..(DB/DEC)..  ...(DB)...     ..(US)..   ....(MHZ).....    (IN)    (FT)   (DEG)

01 WEATH RAD    9335.    9415.   190.   640.   20.   40.   73.  -10.P0      2.3 1.00   6560.   15000.    24.0    .10    180. 0 1
03 TAC2ABOVE    1025.    1150.   110.   260.   40.   40.   66.    2.P0      3.5 2.50     70.   10000.    44.0   1.00      0. 0 3
04 ATC XPNDR    1090.    1090.  1230. 12800.   20.   40.   57.    2.P0       .4  .05     70.   10000.    43.0   1.50    180. 0 3
05 TAC2BELOW    1025.    1150.   110.   260.   40.   40.   66.    2.P0      3.5 2.50     70.   10000.   110.0   3.14    180. 0 3

                                                  RECEIVERS WITH GOOD DATA

  RECEIVER   LOW FREQ  HI FREQ    BW   IF    SF1    SF2  IM LEV SP LEV  LOW SRL  HI SRL LOP Z-DIST  HT    ANG  R  SENS     GAIN    S/1
             ......(MHZ)......  (KHZ)(MHZ) .(DB/DEC).   ....(DB).....  .....(MHZ).....      (IN)  (FT) (DEG)     ........(DB)........

01 WEATH RAD    9335.    9415. 1000.   30.  100.   600.    60.    60.   6560.   10000. A  24.0   .10  180. 0 -104.0  -10.0   10.0
02 GLI SLOPE     329.     335.   80.   51.  100.    60.    70.    80.    200.     400. B   8.0   .64  180. 0 -101.0    2.0   20.0
03 TAC 2A LF     962.    1024.  325.   63.   80.    40.    60.    60.    880.    1150. A  44.0  1.00    0. 0  -90.0    2.0   10.0
03 TAC 2A HF    1151.    1213.  325.   63.   80.    40.    60.    60.   1030.    1330. B  44.0  1.00    0. 0  -90.0    2.0   10.0

 NUMBER OF TRANSMITTERS   NUMBER OF RECEIVERS   KNIFE EDGE LOCATION(INCHES)    KNIFE EDGE HEIGHT(FEET)
         11                       20                       36.0                          1.38

EQUIPMENTS CAUSING POSSIBLE INTERFERENCE (POWER IN GREATER THAN RECEIVER SENSITIVITY)

TRANSMITTER  RECEIVER         S/I  +   PT  +   LF  +   GT  +   GR  -   LP  =   PI    >    RS . . . . . . REMARKS


01 WEATH RAD 09 DOPL RAD      10. +   73. +  -80. +  -10. +  -20. -   92. = -119.        -120.       LK=  27.

03 TAC2ABOVE 04 ATC XPNDR     10. +   66. +    0. +    2. +    2. -   62. =   18.         -74.

          CULLED EQUIPMENTS (POWER IN IS LESS THAN RECEIVER SENSITIVITY)

TRANSMITTER  RECEIVER         S/1  +   PT  +   LF  +   GT  +   GR  -   LP  =   PT    <    RS . . . . . . REMARKS


01 WEATH RAD 02 GLT SLOPE     20. +   73. + -212. +  -10. +    2. -   44. = -171.        -101.
             03 TAC 2A LF     10. +   73. + -133. +  -10. +    2. -   74. = -132.         -90.       LK=  27.
             03 TAC 2A HF     10. +   73. + -134. +  -10. +    2. -   74. = -133.         -90.       LK=  27.
   TABLE OF INTERFERING EQUIPMENTS (X=INTERFERING)

TRANSMITTER                          RECEIVERS                                                       RECEIVER CODES

                0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1
                1 2 3 3 4 5 5 6 6 7 7 8 9 0 1 2 2 3 4 5
              . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .

01 WEATH RAD                            X                                                      01 WEATH RAD

03 TAC2ABOVE            X X X     X X         X X                                              02 GLT SLOPE

04 ATC XPNDR      X X X   X X     X X         X X                                              03 TAC 2A LF

05 TAC2BELOW      X X X X         X X         X X                                              03 TAC 2A HF

06 UHF COMM       X             X                 X                                            04 ATC XPNDR

06 VHF COMM 2                 X       X       X X X                                            05 TAC 2B LF

07 TAC1ABOVE        X X X X X                 X X                                              05 TAC 2B HF
```

Figure 4-1. Typical Output Data.

The analysis results are presented in terms of equation (3-5). Each of the columns is self-explanatory except for the remarks column, which is discussed below. The first set of listings shown are those transmitter-receiver combinations for which potential interactions are predicted. For each potential interfering transmitter, all of the potential victim receivers are shown with the computed value of each term in the expression.

After all of the potential interactions have been listed, those transmitter-receiver combinations for which no interference is expected are shown with the computed values of the terms in the expression. This listing contains those equipment combinations which require no further examination.

At the end of the list containing the "culled," i.e., eliminated, combinations, a matrix is provided which summarizes the expected transmitter - receiver pairs for which potential interference is predicted. This matrix is provided only as a convenient qualitative quick-reference for the analyst.

The remarks column contains special notations which are relevant to the analyses. Five remarks are possible, as discussed below:

### Curvature Range Exceeded

This remark indicates that the portion of the path loss due to the curvature along the path exceeds 100 dB, the upper limit predicted for the curvature factor. When this situation occurs, the model assumes that the curvature factor is 100 dB and proceeds with the computation.

### Frequency is Too Low

As explained in Section 3, when the operating frequency is too low, the assumptions used in developing the path loss model may become invalid. When such a situation arises, the program makes no computation and a manual analysis is required. The present lower limit used in the analysis is 30 MHz.

### Antennas Are Too Close

When two antennas are too close to enable a calculation of path loss, the program assumes that the loss is 0 dB. It then examines the transmitter receiver pair involved based on the remaining parameters and either retains or eliminates the comination on this basis. An example of this arises with the antenna on the Sabreliner which is shared by a VHF transceiver and the UHF transceiver.

**$H = 2, 3, 4 \ldots 9$**

When the worst case interaction has been determined to be due to a harmonic emission rather than the fundamental emission of a transmitter, the interfering harmonic is noted.

**$L_k = X$ dB**

This remark indicates that the path between the transmitter-receiver pair being examined involved a knife-edge obstruction due to the nose bulkhead. The amount of additional loss which has been automatically included in the path loss computation is noted for information purposes.

### Suggested Operating Procedures

This discussion contains the suggested procedures to be followed during an analysis to enable successive levels of refinement with a minimum of manual computation.

### First Level Analysis

The first level analysis is intended to eliminate from further consideration those combinations of equipments which are not expected to result in interactions under any operating conditions. During this phase, the full tuning range of the equipments should be used as input parameters, the specified receiver spurious response limits should encompass all of the potentially susceptible frequencies over the tuning ranges, the minimum spurious response rejection should be used, and the specified degradation threshold should indicate the maximum required S/I ratio for the receiver involved. At the completion of this phase, the equipment combinations satisfying the following conditions will be retained for further attention:

1. Equipments with overlapping or immediately adjacent operating frequency ranges.
2. Equipments with harmonically related operating frequency ranges for which the harmonic attenuation offered by the transmitter is inadequate to preclude interference.

As an illustration of representative results of this level of analysis, a typical problem was solved on the computer for the Sabreliner aircraft. The analysis consisted of evaluating the potential interactions between 11 transmitters and 21 receivers. One reason for the large number of receivers is that each TACAN receiver can operate in one of two split frequency ranges utilizing one of two alternate antennas. Accordingly, the two TACAN receivers required 8 sets of data cards for an adequate description.

With this equipment complement, there were 207 possible interactions to be considered. The first level analysis described above identified 40 potential interactions requiring further examination and eliminated the remaining 167 possible situations. The running time for the computer was 25 seconds.

It should be noted that, since the program does not presently consider the polarization mismatch loss as explained in Section 3, this factor should be included manually at the completion of the automated first level analysis. This may result in additional equipment pairs being eliminated.

**Second Level Analysis**

The transmitter-receiver pairs retained as potential problems after the first level analysis can be subjected to a more refined study to determine the expected mutual effects. Two approaches to the second level analysis are possible, depending on whether the actual equipment operating frequencies are known.

If the actual operating frequencies are not known, then the second level analysis can provide information relating to required frequency separations which preclude degrading interference interactions. In order to make this type of determination, each transmitter, and the receiver for which it is a potential source, is submitted as a separate problem.

When the input data cards are prepared for the transmitter, they are completed exactly as was done in the first level analyses, except that several combinations of discrete operating frequencies are used. Several sets of cards are prepared for the transmitter, each with a difference in operating frequency equal to the appropriate channel separation. For example, the data cards for the VHF communications transmitters would have operating frequencies separated by 50 kilohertz. The user should be careful to modify the transmitter description (Col. 3 to 12) slightly for each operating frequency so that the output results can be correlated properly.

The input data cards for the potential victim receivers are also modified slightly for the second level analyses. One set of data cards is required for each receiver. In this instance, however, the input discrete operating frequency is specified at either the upper, or lower, frequency within the operating range of the receiver. In addition, the limiting frequencies at which spurious responses are a potential problem are modified to reflect the expected receiver susceptibility to this interference mechanism at the discrete operating frequency specified as an input. If desired, these spurious response limits may be specified to reflect the assymetry noted previously. If this is done the operating frequency should be specified at the upper

end of the operating-range if the local oscillator operates below the tuned frequency, and vice versa, in order to insure that this type of interaction is given proper consideration.

In other words, each combination of transmitters and receivers retained as potential interference problems by the first level analysis is further evaluated in the second level analysis by sequentially studying the reduction in the expected effects as the difference between the equipment operating frequencies is increased.

This level of analysis can be expected to enable removal from further consideration the interactions expected due to harmonically related equipment operating frequencies and those interactions involving equipments with immediately adjacent operating frequency ranges for which no spurious responses can be expected under worst case conditions. Of course, the required frequency separations resulting from this level of analysis must be respected to preclude these interactions.

If the respective operating frequencies are known, the input data can be submitted to reflect these frequency relationships and the results obtained will reflect this situation also. This raises the immediate question concerning the need for a two-level analysis if the actual operating frequencies are known. The response to the question is that there is, in fact, no need for the first level analysis if the operating frequencies are known, provided, of course, that these frequencies will never be changed.

The first level analysis will eliminate from further consideration, including future considerations, those equipment combinations for which interactions are not expected under any possible assignment of operating frequencies. The generalized second level analysis will provide frequency assignment guidelines which will preclude undesirable interactions under any assignment of frequencies provided the guidelines are met.

The particular analysis based on specific operating frequencies provides results which may be applicable only to the set of operating frequencies submitted at the time.

Thus, it is recommended that specific operating frequencies be submitted on inputs only after two levels of generalized analysis have been accomplished and generalized conclusions have resulted.

**Third Level Analysis**

The equipment combinations expected to be retained as potential interference problems after the second level analysis are those sharing the same or immediately adjacent operating

frequency ranges for which the path loss is inadequate to preclude spurious response interference interactions with an acceptable or realizable separation in the equipment tuned frequencies.

Other non-linear effects, such as cross modulation, desensitization, and intermodulation must also be considered during this level of analysis. The latter non-linear effects can be omitted from the first two levels of effort since they do not arise between avionics equipments operating in widely separated frequency bands.

Because of the detailed nature of the analysis required for responsible conclusions pertaining to non-linear effects, the third level of analyses is necessarily accomplished manually. In performing this type of study, due consideration must be given to the receiver detection process and nature of the potential interfering signal in order that the degradation threshold may be adjusted along with the frequency relationships discussed previously.

If examination of potential interactions due to receiver spurious responses is required, the receiver must be modeled to reflect each individual response for which the path loss is inadequate to preclude a degrading interaction. This modeling is accomplished by rearranging equation (3-5) to provide for a solution of the frequency rejection term, $L_f$ required to preclude degradation, and then determining the appropriate value of spurious response rejection, $K_s$, using the procedures set forth in SECTION 3. In this instance, $L_f$ and $K_s$ are identical factors.

The expected occurrence of degradation due to cross modulation and desensitization can be estimated by assuming that the receiver input on-tune susceptibility for this phenomenon is −20 dBm. The effective rejection of the receiver to this phenomenon is determined by calculating the selectivity characteristic of the first RF amplifier. This characteristic can be calculated using the methods described in SECTION 3, but it must be emphasized that only the tuned circuits associated with the input and output of the first RF amplifier should be used in determining this selectivity characteristic.

Interference due to intermodulation can be ignored on most airplanes. Degradation in avionics equipment due to this phenomenon requires the simultaneous operation of at least two transmitters and one receiver in the same operating frequency range.

## Additional Applications

The model presented herein can be used to determine the expected effects of future equipment installations as well as the effects of existing complements on any airframe. This is

accomplished by the following sequence:

1. Prepare input data cards describing the proposed equipment using the most operationally desirable location on the airframe to determine the required geometrical parameters.
2. Perform two levels of analysis as discussed herein.
3. If necessary, perform a third level analysis to determine the maximum frequency rejection that can be expected between the potentially troublesome equipment combinations.
4. Solve equation (3-5), using this maximum frequency rejection, to determine the path loss required for compatible operations.
5. Perform an analysis using the optimum frequency dependent input parameters as constants and varying the proposed location to determine the expected path losses.
6. Decide on the operational practicality and suitability of the proposed system when the maximum expected path loss is determined.

# SECTION 5

# SABRELINER EMC EVALUATION

## Introduction

The entire avionics complement on the Sabreliner was subjected to three levels of analysis as described in SECTION 4 of this report. In addition to the existing equipments, a proposed VHF SATCOM terminal was evaluated, although the evaluation of this installation was not made until the third level of analysis.

## First Level Analysis Results

The input data used for the first level analysis are shown in APPENDIX V. The results of this analysis are shown in the form of a matrix in TABLE 5-1. Those equipment combinations denoted by an "X" in this table were retained as potential interference problems. The combinations denoted by a blank space were eliminated from further consideration. Each of the equipments involved may be identified by referring to Figure 3-1 and TABLE 3-2.

TABLE 5-1
FIRST LEVEL ANALYSIS RESULTS

| Transmitter | Receiver Antenna Number | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Antenna No. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| 1. Weather Radar | | | | | | | | | | | | | | | |
| 3. TACAN-2 | | | | X | | | X | | | | | X | | | |
| 4. ATC | | | X | | X | | X | | | | | X | | | |
| 5. TACAN-2 | | | | X | | | X | | | | | X | | | |
| 6. VHF Comm. | | | | | | X | | X | | | | | X | X | X |
| 6. UHF Comm. | | X | | | | | | | | | | | | | |
| 7. TACAN-1 | | | X | X | X | | | | | | | | | | |
| 8. VHF Comm. | | | | | | X | | | | | | | X | X | X |
| 9. Doppler | | | | | | | | | | | | | | | |
| 11. Altimeter | | | | | | | | | | | | | | | |
| 12. TACAN-1 | | | X | X | X | | | | | | | | | | |

## Second Level Analysis Results

A second level analysis was performed as described in SECTION 4. Because of the relatively

small size of the Sabreliner, and the concomitantly small coupling losses, the only equipment combinations eliminated were the VHF communications transmitters and the UHF communications and UHF direction finding receivers. These equipments were eliminated as interference situations as soon as the harmonic relationship between the respective operating frequencies no longer existed. The equipment combinations remaining after this level of analysis were:

1. TACAN versus the ATC transponder.
2. TACAN transmitters versus the TACAN receivers.
3. VHF Communications Transmitters versus VHF Communications receivers.
4. VHF Communications Transmitters versus VHF navigation receivers.
5. The UHF Communications Transmitter versus the Glide Slope receivers.

### Third Level Analysis Results

Each of the Sabreliner equipment combinations retained after the second level analysis was subjected to a detailed manual analysis to establish the frequency separations required to preclude degrading interference. In addition, the expected mutual effects due to the installation of a VHF Satellite Communications (SATCOM) terminal were determined during this phase of the study. These predictions are based on nominal equipment characteristics as published by the manufacturers involved rather than measured characteristics obtained from an adequate sampling of the equipment. Because of this, some variation from the predicted results can be expected during actual operations. Further, operational considerations have not, in general, been considered. Such considerations could affect the frequency of observation of the predicted effects.

### TACAN Transmitter Effects on the ATC Transponder

The TACAN transmitted pulses will not result in degrading interference to the ATC Transponder receiver because blanking pulses are provided by the TACAN equipment which disable the transponder for the period of each TACAN transmission. If this were not the case, serious effects could be expected, since the input interfering signals from the TACAN, which can reach a peak level as high as 32 dBm, might result in damage to the input circuitry of the transponder receiver as well as interference due to spurious responses and adjacent channel effects. Further, interference due to TACAN interpulse CW is not expected, since the TACAN local oscillator signal is prevented from reaching the transmitter power amplifiers by a diode switching circuit.

### ATC Transponder Effects on the TACAN Receiver

The TACAN receivers have a Yttrium Iron Garnet (YIG) input filter which limits all

input signals to a maximum level of 10 dBm, thereby precluding any high power interference effects in these receivers. However, the determination of the interactions which are to be expected between these equipments is beyond the scope of this study, for the following reasons:

1. Each TACAN receiver operates in conjunction with two antennas. The antennas are alternately switched into the receiving system to insure that the best quality signal is obtained. Thus, the effect of an interfering signal impinging on the antennas depends on which antenna is in use and the time relationships between the interfering signal, the desired signal, and the antenna switching doctrine.

2. The detection circuitry in the TACAN receivers is such that when a pulsed signal is received and recognized, a timing circuit is enabled, which counts for twelve microseconds, nominally. At the end of this period of time, a gate is enabled. If a second pulsed signal is recognized during the interval in which the gate is enabled, an output is provided; otherwise, the receiver ignores the first pulse and no output results. Thus, the effect of a pulsed interfering signal on the TACAN receiver depends on the interpulse spacing of the interference, and the time relationship between reception of the interfering pulses and the desired TACAN pulses.

3. The ATC Transponder emissions consist of a coded train of pulses. A total of 4096 different codes is possible, of which 64 selected codes are presently used. The spectral characteristics of the emissions, and the resulting effects on the TACAN receivers will change as different codes are used. For example, if a 7777 or a 7700 transponder code is used, the pulse train duty cycle will be 0.5 and 0.25, respectively. Under these conditions, the TACAN receiver will achieve a steady state response during the pulse train and no second pulse will be detected during the gate interval. If a 1311 or 0100 code is used, an interval of approximately 12 microseconds will exist between certain of the pulses in the train and an erroneous output is possible, depending on the time relationships between the interfering pulse train and the reception time of the desired TACAN pulses.

4. Each individual ATC Transponder pulse has a duration of 0.45 microseconds, a rise time between 50 and 100 nanoseconds, and a fall time between 50 and 200 nanoseconds. Although 50 nanosecond rise and fall times represent the design goals and the expected capabilities of the equipment, the maintenance procedures provide for go-no go acceptance criteria of 100 nanoseconds and 200 nanoseconds for the rise and fall times, respectively. Further, it should be noted that in spite of the generation of the pulses in the modulator as trapezoidal pulses, the output of the transmitter RF stage is taken from a cavity resonator, which will tend to shape the output pulses. It can be shown that the spectral characteristics of the output pulses change sufficiently as these parameters are varied to enable either a conclusion that interference to TACAN could result, if the appropriate codes were used at all possible frequency separations, or a conclusion that no interference would result at the

minimum separation (approximately 60 MHz) under any of the possible codes.

Accordingly, an extensive, statistical effort would be required to make estimates of the expected effects of the Transponder on the TACAN receivers. Since such a study was not a goal of this effort, it will suffice to state qualitatively that degradation to the TACAN receivers as a result of the transponder emissions is possible but not probable.

### Mutual Effects Between TACAN Systems

The expected mutual effects between the TACAN systems on the Sabreliner are nearly as difficult to determine as the effects due to the ATC Transponder, because of the technique employed to switch the antennas associated with each equipment. One significant difference to be considered, however, is that the TACAN transmitters emit a signal which will always satisfy the TACAN detection criteria. Therefore, a worst case determination was possible and it was found that degrading interference could result due to the sideband energy of one system transmitter occurring within the IF passband of the second systems receiver, unless the separation in the respective tuned frequencies is greater than 9 MHz. Further, interference may also result when the transmitting frequency of one TACAN system falls on the image frequency of the other system receiver. The image frequency of a TACAN receiver is located 126 MHz above or below the receiver tuned frequency, depending on whether the receiver is operating in the lower or upper portions, respectively, of its overall tuning range. If the output pulses of the transmitters were synchronized in time, no degradation would ever occur since the receiver would not be operative when the impinging undesired signals arrived.

### Mutual Interactions Between the VHF Communications Equipments

The communications receivers were modeled as previously described and the expected effects due to the transmitters were determined. Mutual interference between the VHF systems can be expected if the frequency separation between the systems is less than 1.8 MHz.

The interference will be caused by the spectral energy contained in the noise sidebands of the transmitter which fall within the receiver passband. The degradation threshold used to evaluate this effect was 10 dB. This threshold was used because the interference signal will appear as noise to the receiver. The emission characteristics of the transmitter were modeled in the manner described in SECTION 3.

### VHF Communications Transmitter Effects in the VHF Navigation Receivers

The noise sidebands of the VHF communications transmitters will result in degrading

interference to the VOR/ILS receivers if the frequency separation between these equipments is less than 0.3 MHz. The interaction will arise in the same manner described above. Since the interfering signal appears as noise to the receiver, a degradation threshold of 10 dB was used.

### Effects of the UHF Transmitter on the Glide Slope Receivers

The emissions from the UHF communications transmitter can result in degrading interference to the Glide Slope receivers by exciting a spurious response in the receiver, and by exciting a response within the receiver passband due to the transmitter noise sidebands. The spurious responses which could arise include the receiver image response and the response which arises when the frequency separation is one-half of the intermediate frequency ($p = q = 2$ in equation 3-20b). These potential spurious interference situations can be precluded by insuring that the UHF transmitter is not tuned 102.4 MHz ±60 kHz, or 25.6 MHz ±50 kHz below the tuned frequency of the Glide Slope receiver. Degrading interference due to the noise sidebands of the transmitter can be avoided if the separation between the tuned frequencies of the equipments is 0.6 MHz or greater.

### Expected Effects of Future VHF SATCOM Terminal

Since the detailed characteristics of the equipment to be used for future voice communications using a satellite are not fully known, certain assumptions had to be made to enable an evaluation of the impact of such a terminal. These are:

1. The SATCOM receiver characteristics were assumed to be identical to those of the existing Sabreliner VHF communications receivers, except that the sensitivity has been increased to – 111 dBm, rather than –97 dBm, in accordance with ARINC characteristic 566.
2. The SATCOM transmitter terminal was assumed to have identical characteristics compared to the existing VHF transmitters, except that the output power will be 500 watts.
3. The SATCOM antenna will be circularly polarized with 0 dBi gain as set forth in ARINC Characteristic 566 and will be located on the top centerline of the Sabreliner fuselage approximately at Frame Number 135.
4. The VHF SATCOM terminal will never be used simultaneously with the existing VHF communications system whose antenna is installed on the top centerline at Frame Number 168 i.e., the use of both of these systems is assumed to be mutually exclusive.

Based on these assumptions, it was found that the proposed SATCOM Terminal would result in degrading interference to the VHF navigation receivers and in mutual interference with the VHF communications system located on the bottom centerline at Frame Number

135. In each instance the interference effects will result from the noise sidebands of the transmitters involved. Degradation in the VHF navigation receivers can be avoided if the SATCOM transmitter frequency is separated by at least 15 MHz from the receiver tuned frequencies, i.e., no degradation will result if the SATCOM frequency is above 133 MHz.

Mutual interference between the VHF communications systems can be precluded if the frequency separation between the respective tuned frequencies is at least 4.2 MHz. It should be noted that this restriction is applicable in both directions. The existing VHF communications transceiver has a transmitter output power of 25 watts and a receiver sensitivity of −97 dBm. The proposed SATCOM equipment has a transmitter power of 500 watts and a receiver sensitivity of −111 dBm. Thus, the difference in transmitter powers of 13 dB virtually offsets the difference in receiver sensitivities (14 dB) for interference calculations.

No other interference is expected provided that harmonic relationships between the operating frequencies of the SATCOM system and the remaining receiving systems on board are avoided when making frequency assignments.

# SECTION 6

# MODEL EXPANSION POSSIBILITIES

## General

As stated previously, the development of the prediction model in the form of an expression has resulted in an inherent modular characteristic which is amenable to expansion and modification. This section will provide a discussion of possible improvements and the methods viewed as providing promise toward realization of a full prediction model.

## Antenna Gain Calculator

First, it was mentioned in SECTION 3 that an antenna gain subroutine could be developed which would calculate the gain expected from any antenna on the aircraft. This parameter is currently obtained from manufacturers information or, in the case of aperture antennas, modeled theoretically using manual techniques. Both of these methods could be accomplished by automating the expressions used by an engineer to provide the input data required herein. In addition, the required information could be converted into a statistical parameter by obtaining sufficient information to confidently predict the expected variations in antenna characteristics due to different manufacturers, different antenna types, different aperture sizes and different scanning principles, as appropriate, between antennas performing the same functional mission. A probabilistic representation of antenna gains would also be more meaningful for considerations involving aircraft-to-aircraft or aircraft-to-ground environment problems where perturbations in antenna gain could be expected due to irregularities in airframe geometry, and scanning principles versus aircraft or ground equipment orientation and location.

## Improvement In Coupling Loss Predictions

A second area of possible expansion involves improvement of the path loss prediction to include the expected range of errors involved in the theoretical calculations. As mentioned in SECTION 3, the errors experienced between previous predictions and actual observations can be expressed statistically. Further, it is suggested herein that the coupling losses predicted between Sabreliner equipments be verified and reported to the ECAC. When this has been accomplished, the observed variations should be used to improve the prediction model using statistical techniques.

### Input Preprocessor

As indicated in SECTION 3, the model can also be expanded and improved by development of an automatic pre-processor which will minimize the number of required input data as well as the effort required to obtain them. This approach will be mandatory if the model is expanded to enable consideration of an aircraft-to-ground environment prediction process. The most extensive environmental data base known to exist in the world is maintained by the ECAC, but the format of these files is not immediately amenable to a realistic solution of this type of problem without a buffering pre-processor as contemplated herein. This pre-processor could also be developed to reflect expected variations in statistical terms, although the time required to describe the ground equipments in this manner would be substantial.

### Statistical Prediction Model

The remaining parameters shown in Equation (3-5), which are largely input parameters describing equipment performance, could be expressed statistically by determining the variations expected among equipments used for the same functions on different airframes as supplied by different manufacturers. The development of such a variational representation would require interchanges of information between the developer and airframe manufacturers, airline users, equipment manufacturers, and the military services, or an agency familiar with military equipment installation, performance, and operation, such as ECAC.

### Suggested Improvement Sequence

A sequential improvement and expansion program is suggested herein. Certain of the steps could be accomplished simultaneously. The steps indicated follow a sequence which is convenient, without regard to operational necessities. They are:

1. Develop an input pre-processor for the existing model using deterministic expressions, which will minimize the number of required input parameters.
2. Develop an antenna gain subroutine which includes a calculation of expected gain and polarization mismatches, and results in an effective mutual gain calculation between antennas on an airframe.
3. Expand the coupling loss subroutine to reflect the distribution of expected errors, including the errors previously observed as well as those observed by FAA when verifying the predictions reported herein.
4. Expand this overall model to incorporate different coupling loss models and expand the prediction capability to enable estimates of interactions in an aircraft-to-environment (both airborne and ground) situation.
5. Convert the prediction techniques to enable calculations in probabilistic terms.

# APPENDIX I

## COUPLING LOSS SUBROUTINE

This Appendix contains the flow diagram and program listing for the subroutine used to compute the expected path loss between two antennas on an airframe. The flow chart is shown in Figure I-1. The program listing, which is written in the FORTRAN V language, is shown in Figure I-2.

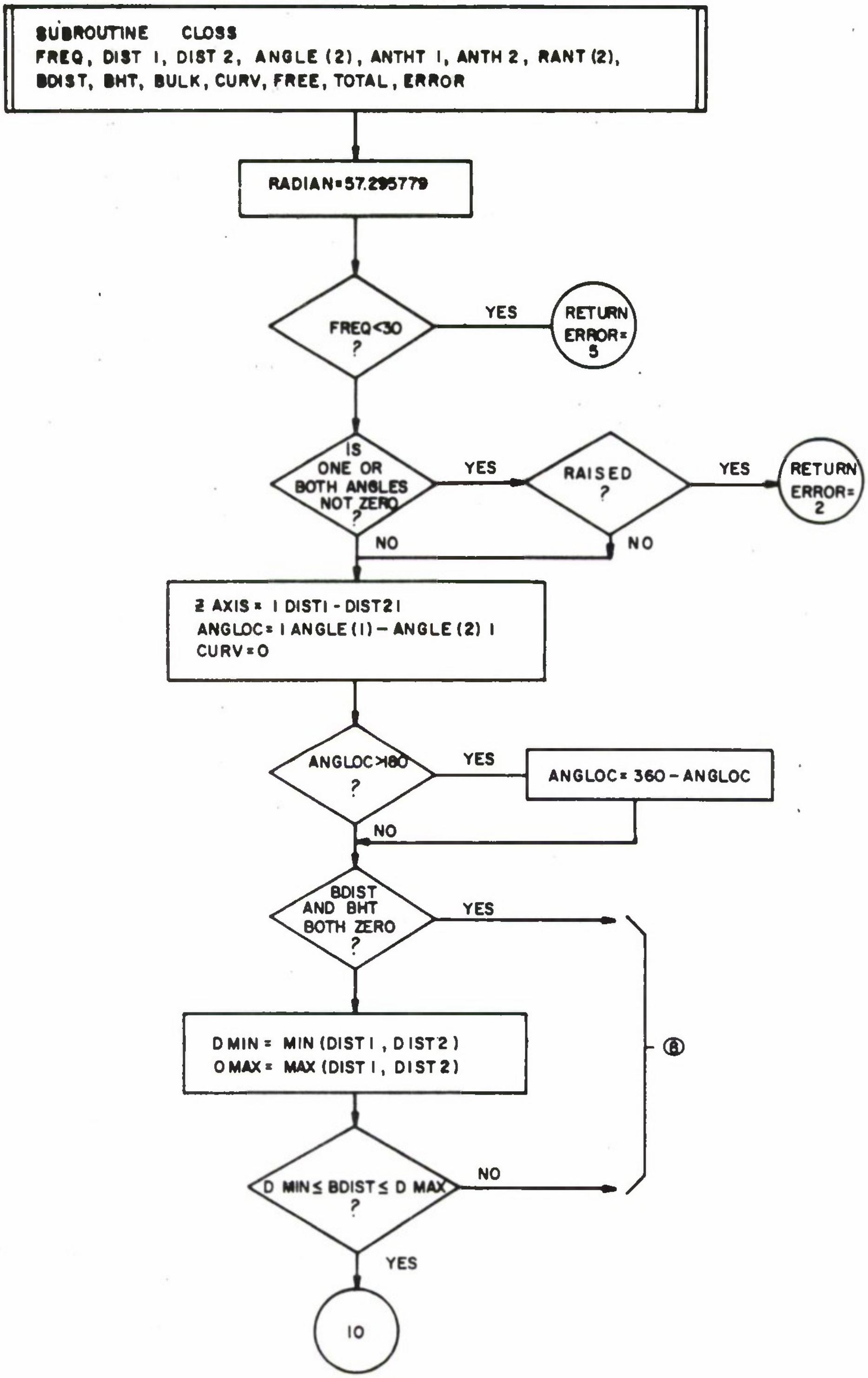


Figure I-1. Coupling Loss Subroutine Flow Diagram.

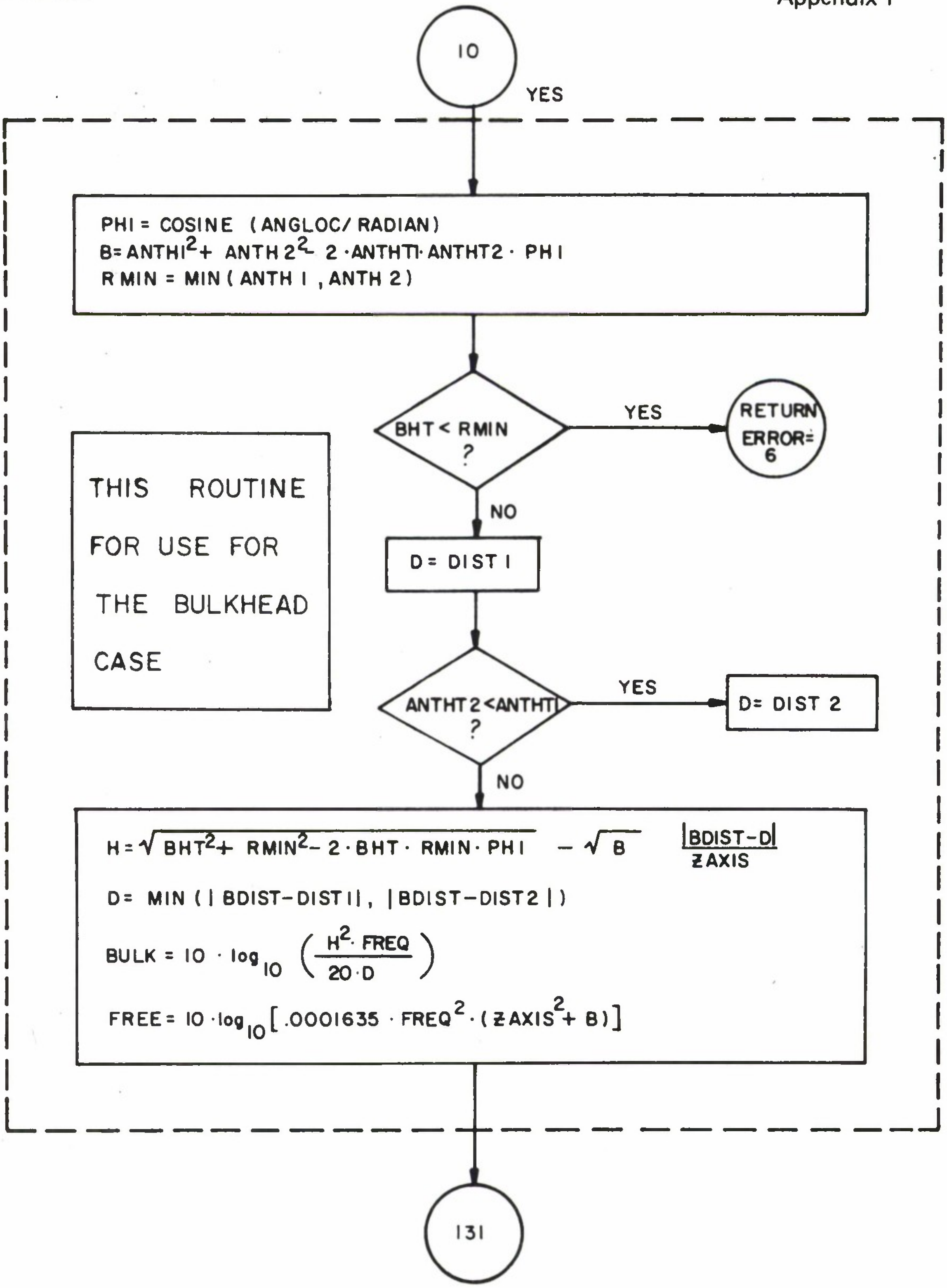


Figure I-1. (Continued)

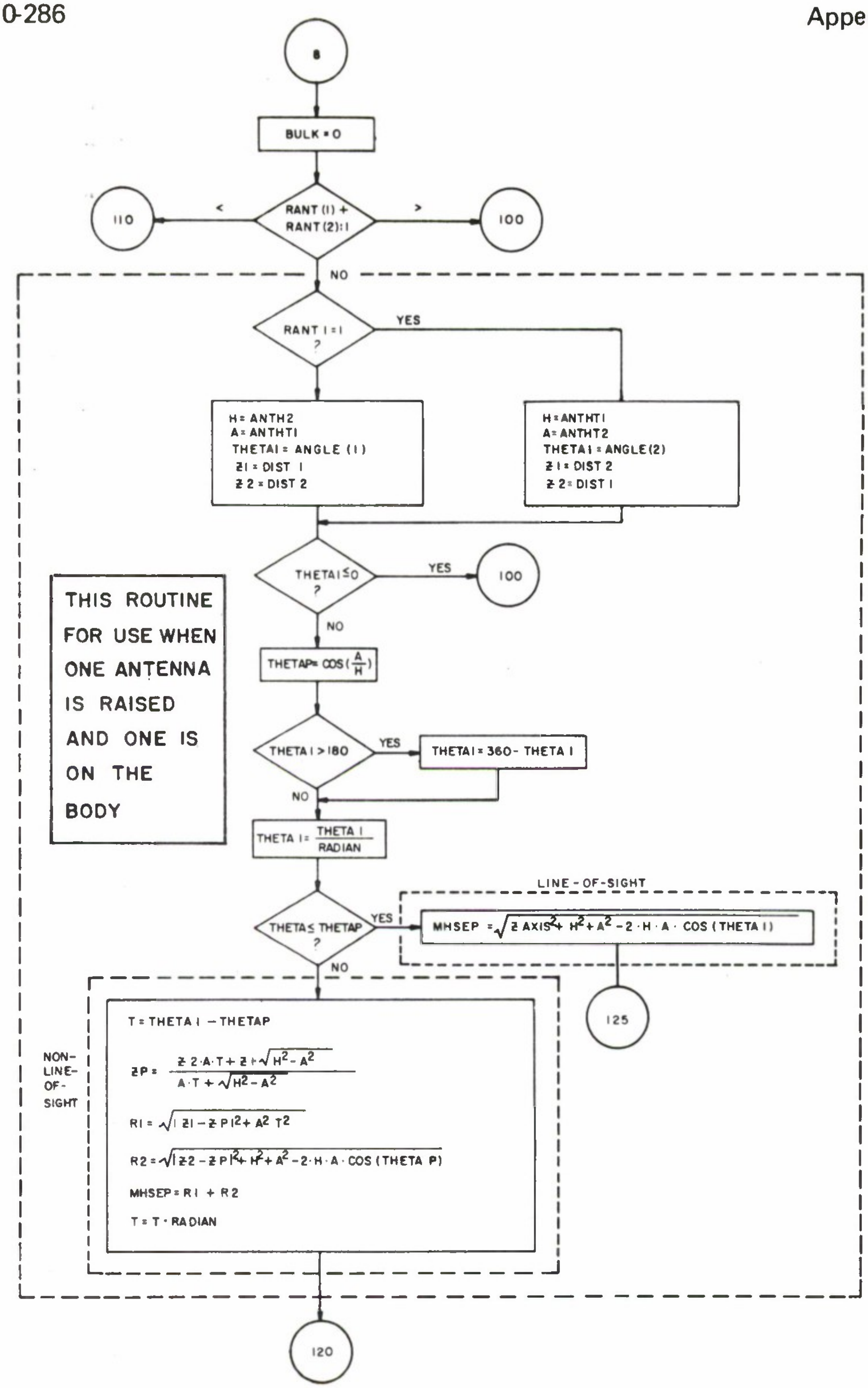


Figure I-1. (Continued)

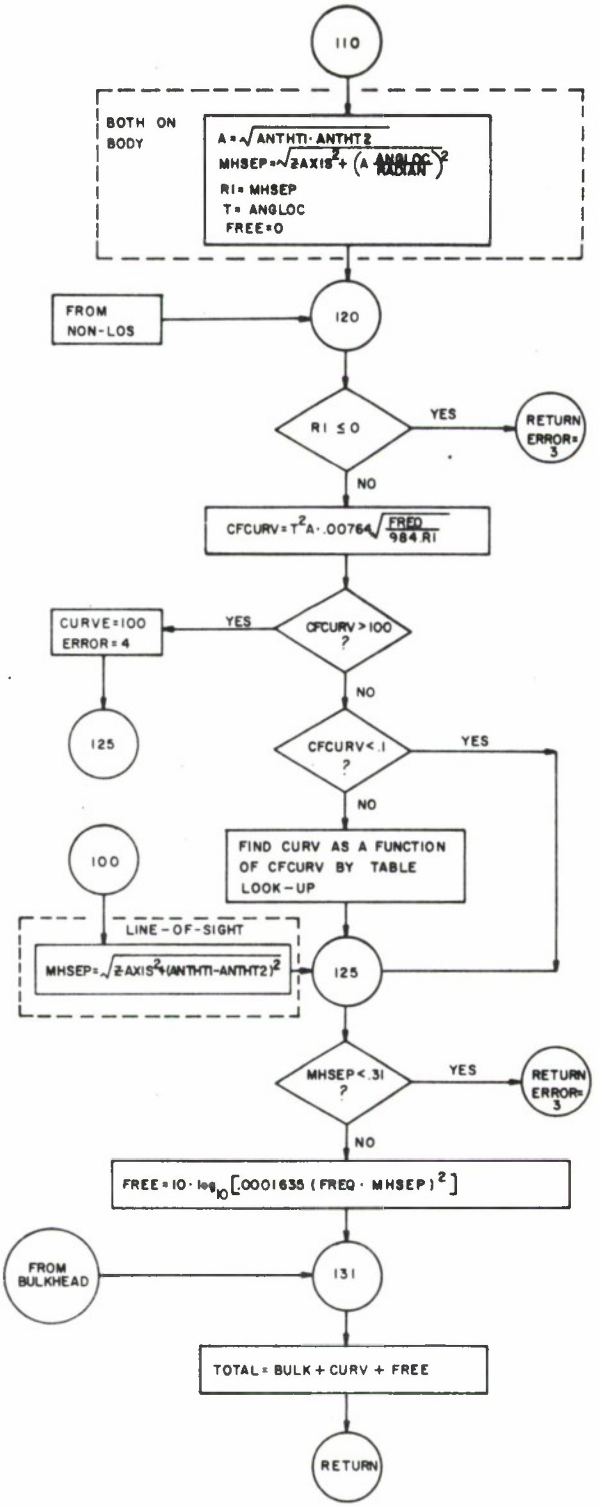


Figure I-1. (Continued)

```
SUBROUTINE CLOSS      ENTRY POINT 001001

STORAGE USED (BLOCK, NAME, LENGTH)

      0001    *CODE    001010
      0000    *DATA    000147
      0002    *BLANK   000000
      0003    CLCOMM   000020


EXTERNAL REFERENCES (BLOCK, NAME)

      0004    INTRUP
      0005    COS
      0006    SQRT
      0007    ALOG10
      0010    ACOS
      0011    NERR6$
      0012    NERR3$


STORAGE ASSIGNMENT FOR VARIABLES (BLOCK, TYPE, RELATIVE LOCATION, NAME)

 0001     000520 100L        0001     000534 110L        0001     000561 120L        0001     000721 125L        0001     000034 12L
 0001     000631 127L        0001     000655 128L        0001     000656 129L        0001     000745 130L        0001     000740 131L
 0001     000750 140L        0001     000754 150L        0001     000760 152L        0001     000763 154L        0001     000765 160L
 0001     000050 20L         0001     000610 2636        0001     000054 30L         0001     000323 50L         0001     000335 55L
 0001     000276 8L          0001     000415 80L         0000 R 000063 A          0003 R 000003 ANGLE       0000 R 000053 ANGLOC
 0003 R 000005 ANTHT1      0003 R 000006 ANTHT2      0000 R 000057 B          0003 R 000011 BDIST       0003 R 000012 BHT
 0003 R 000013 BULK        0000 R 000076 C           0000 R 000075 CFCURV     0003 R 000014 CURV        0000 R 000102 CURVE
 0000 R 000061 D           0003 R 000001 DIST1       0003 R 000002 DIST2      0000 R 000055 DMAX        0000 R 000054 DMIN
 0003 I 000017 ERR         0003 R 000015 FREE        0003 R 000000 FREQ       0000 R 000062 H           0000 I 000051 I
 0000   000123 INJP$       0000 I 000050 1$          0000 R 000000 MHSEP      0000 R 000072 P           0000 R 000056 PHI
 0000 R 000024 PM          0000 R 000047 RADIAN      0003 I 000007 RANT       0000 R 000060 RMIN        0000 R 000073 R1
 0000 R 000074 R2          0000 R 000070 T           0000 R 000067 THETAP     0000 R 000064 THETA1      0003 R 000016 TOTAL
 0000 R 000077 XA          0000 R 000100 XB          0000 R 000101 XC         0000 R 000001 Y           0000 R 000052 ZAXIS
 0000 R 000071 ZP          0000 R 000065 Z1          0000 R 000066 Z2


00101      1*         SUBROUTINE CLOSS
00103      2*         COMMON/CLCOMM/FREQ,DIST1,DIST2,ANGLE(2),ANTHT1,ANTHT2,RANT(2),
00103      3*        .   BDIST,BHT,BULK,CURV,FREE,TOTAL,ERR
00104      4*         INTEGER RANT,ERR
00105      5*         REAL MHSEP
00106      6*         DIMENSION Y(19),PM(19)
00107      7*         DATA RADIAN/57.295779/
```

Figure I-2. Coupling Loss Subroutine Listing.
(page I of 4)

```
00111              DATA             Y / .1,.2, .3,.5,.7,1., 2.,3.,5., 7.,10.,15.,
00111            120., 25., 30., 40., 45.,50., 100. /
00113              DATA  PM           / .2,.4,.6, 1.,1.3, 1.9,3.9,5.7,9.4,12.9,17.5,
00113            125.5,32.3,39. ,45.,57., 62.5,67.5,100. /
00115              FUNCT(W)=10.*ALOG10(.0001635*W)
00116              CALL INTRUP(0)
00117              BULK=0.
00120              CURV=0.
00121              FREE=0.
00122              TOTAL=0.
00123              IF(FREQ.LT.30.)GO TO 152
00125              ERR=1
00126              DO 30 I=1,2
00131              ANGLE(I)=AMOD(ANGLE(1),360.)
00132              IF(ANGLE(1))10,30,20
00135           10 ANGLE(1)=ANGLE(I)+360.
00136           20 IF(RANT(I).EQ.1)GO TO 130
00140           30 CONTINUE
00142              ZAXIS=ABS(DIST1-DIST2)
00143              ANGLOC=ABS(ANGLE(1)-ANGLE(2))
00144              IF(ANGLOC.GT.180)ANGLOC=360.-ANGLOC
00146              IF(BDIST*BHT)8,8
00151              DMIN=AMIN1(DIST1,DIS)2)
00152              DMAX=AMAX1(DIST1,DIST2)
00153              IF(BDIST.LT.DMIN)GO TO 8
00155              IF(BDIST.GT.DMAX)GO TO 8
00155        C
00155        C**   BULKHEAD CASE
00155        C
00157              PHI=COS(ANGLOC/RADIAN)
00160              B=ANTHT1**2+ANTHT2**2-2.*ANTHT1*ANTHT2*PHI
00161              RMIN=AMIN1(ANTHT1,ANTHT2)
00162              IF(BHT-RMIN)154
00165              D=DIST1
00166              IF(ANTHT2.LT.ANTHT1)D=DIST2
00170              H=SQRT(BHT**2+RMIN**2-2.*BHT*RMIN*PHI)
00170             .                             -SQRT(B)*ABS((BDIST-D)/ZAXIS)
00171              D=AMIN1(ABS(BDIST-DIST1),ABS(BDIST-DIST2))
00172              BULK=10.*ALOG10(H*H*FREQ/20./D)
00173              IF(BULK.LT.6)BULK=6.
00175              FREE=FUNCT(FREQ**2*(ZAXIS**2+B))
00176              GO TO 131
00176        C
00176        C**   NO BULKHEAD INTERFERES
00176        C
00177            8 IF(RANT(1)+RANT(2)-1)110,40,100
00177        C
00177        C**   ONE ANTENNA RAISED, ONE ON AIRFRAME.
00177        C
00202           40 IF(RANT(1).EQ.1)GO TO 50
00204              H=ANTHT2
00205              A=ANTHT1
00206              THETA1=ANGLE(1)
00207              Z1=DIST1
00210              Z2=DIST2
```

Figure I-2. Continued.

```
00211                 GO TO 55
00212            50   H=ANTHT1
00213                 A=ANTHT2
00214                 THETA1=ANGLE(2)
00215                 Z1=DIST2
00216                 Z2=DIST1
00217            55   IF(THETA1)100,100,60
00222            60   THETAP=ACOS(A/H)
00223                 IF(THETA1.GT.180.)THETA1=360.-THETA1
00225                 THETA1=THETA1/RADIAN
00226                 IF(THETA1-THETAP)70,70,80
00226         C
00226         C**     LINE-OF-SIGHT FROM RAISED ANTENNA TO ONE ON BODY.  COMPUTE DISTANCE.
00226         C
00231            70   MHSEP=SQRT(ZAXIS**2+H*H-2.*H*A*COS(THETA1)+A*A)
00232                 GO TO 125
00232         C
00232         C**     COMPUTE TOTAL DISTANCE FOR NON-LINE-OF-SIGHT CASE.
00232         C
00233            80   T=THETA1-THETAP
00234                 ZP=(Z2*A*T+Z1*SQRT(H*H-A*A))/(A*T+SQRT(H*H-A*A))
00235                 P=ABS(Z1-ZP)
00236                 R1=SQRT(P*P+(A*T)**2)
00237                 P=ABS(Z2-ZP)
00240                 R2=SQRT(P*P+H*H-2.*H*A*COS(THETAP)+A*A)
00241                 MHSEP=R1+R2
00242                 T=T*RADIAN
00243                 GO TO 120
00243         C
00243         C**     LINE-OF SIGHT (ANGLE ZERO)
00243         C
00244           100   MHSEP=SQRT(ZAXIS**2+(ANTHT1-ANTHT2)**2)
00245                 GO TO 125
00245         C
00245         C**     BOTH ON BODY, COMPUTE SEPARATION DISTANCE.
00245         C
00246           110   A=SQRT(ANTHT1*ANTHT2)
00247                 MHSEP=SQRT(ZAXIS**2+(A*ANGLOC/RADIAN)**2)
00250                 R1=MHSEP
00251                 T=ANGLOC
00252           120   IF(R1)140,140,122
00252         C
00252         C**     COMPUTE CURVATURE FACTOR AROUND BODY AND FIND LOSS.
00252         C
00255           122   CFCURV=T*T*A*.000764*SQRT(FREQ/984./R1)
00256                 IF(CFCURV.GT.100.)GO TO 150
00260                 IF(CFCURV.LT..1)GO TO 125
00262                 DO 126 I=2,19
00265           126   IF(CFCURV.LT.Y(I))GO TO 127
00270                 RETURN 0
00271           127   IF(I.EQ.2)GO TO 129
00273                 IF(I.EQ.19)GO TO 128
00275                 IF(Y(I)-Y(I-1)-2.*(CFCURV-Y(I-1)))129,129,128
00300           128   I=I-1
00301           129   U=Y(I+1)-Y(I)
```

Figure I-2. Continued.

```
00302   118*        B=Y(I)-Y(I-1)
00303   119*        C=Y(I+1)-Y(I-1)
00304   120*        XA=Y(I+1)-CFCURV
00305   121*        XB=Y(I)-CFCURV
00306   122*        XC=Y(I-1)-CFCURV
00307   123*        CURV =PM(I-1)*XB*XA/C/B-PM(I)*XA/D*XC/B+PM(I+1)*XB*XC/D/C
00310   124*    125 IF(MHSEP.LT..31)GO TO 140
00312   125*        FREE=FUNCT((FREQ*MHSEP)**2)
00313   126*    131 TOTAL=BULK+CURV+FREE
00314   127*        GO TO 160
00315   128*    130 ERR=2
00316   129*        GO TO 160
00317   130*    140 ERR=3
00320   131*        GO TO 160
00321   132*    150 ERR=4
00322   133*        CURVE=100.
00323   134*        GO TO 125
00324   135*    152 ERR=5
00325   136*        GO TO 160
00326   137*    154 ERR=6
00327   138*    160 RETURN
00330   139*        END
```

Figure I-2. Continued

# APPENDIX II

## COUPLING LOSS MEASUREMENT PROCEDURES

This Appendix contains generalized test procedures which are applicable for the validation of the coupling losses indicated in this report (See Figure 3-3, SECTION 3). Two measurement methods are described, a directly indicating technique for the coupling losses at frequencies below 1000 MHz, and a signal substitution technique for measuring the coupling losses at frequencies above 1000 MHz.

### Direct Measurement Technique

The test equipment configuration to be used for the coupling loss measurement at frequencies below 1000 MHz is shown in Figure II-1.

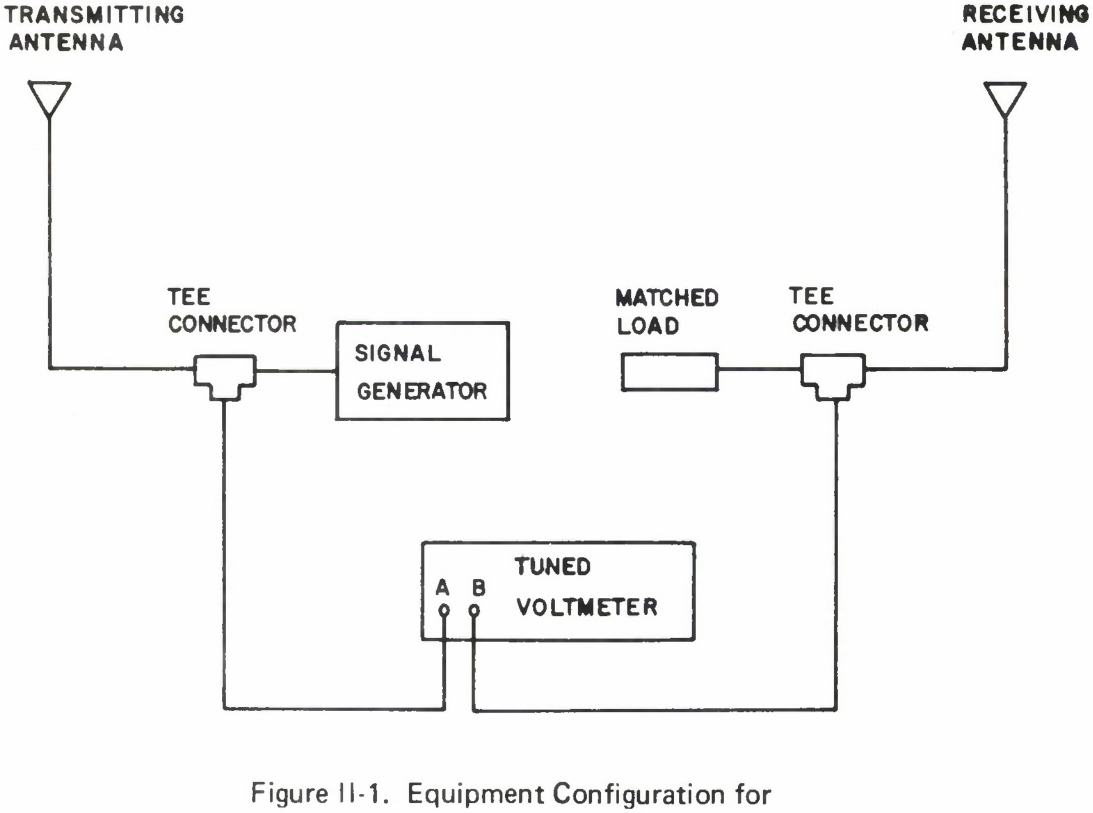


Figure II-1. Equipment Configuration for Measurements Below 1000 MHz.

The types of equipments recommended for use are:

| | Frequency Range | Type |
|---|---|---|
| Signal Generators | 10-480 MHz<br>800-1000 MHz | HP-608E, or equivalent<br>HP-8614A, or equivalent |
| Tuned Voltmeter | 1-1000 MHz | HP-8405A, Vector Voltmeter, or equivalent |
| Tee Connectors | 1-1000 MHz | HP-11570A, Accessory |
| Matched Load | 1-1000 MHz | Kit, or equivalent |

If these equipments are operated in accordance with the manufacturers instructions and in the illustrated configuration, the following parameters can be read directly.

1. The voltage applied to the transmitting antenna. (Channel A).
2. The voltage applied across the matched load of the receiving antenna. (Channel B).

The observed coupling loss is then:

Coupling loss (dB) = 20 log Channel A voltage/Channel B voltage

In performing the measurements, the following procedures should be followed for each transmitting/receiving antenna combination being considered:

1. Disconnect transmission lines associated with the transmitting and receiving equipments under consideration at the input to the respective equipment.
2. Connect the transmitting and receiving transmission lines to the proper tee connectors as shown in Figure II-1.
3. Tune the signal generator to a convenient frequency within the operating range of the transmitter.
4. Tune the voltmeter to the same operating frequency as that of the signal generator.
5. Record the output voltage level of the generator as indicated with the voltmeter selector switch on Channel A.
6. Record the received voltage level as indicated with the voltmeter selector switch on Channel B.

7. Repeat the measurement four additional times at different frequencies within the operating range of transmitter.

8. Reverse the antenna connections and perform the measurement five additional times on the same operating frequencies previously used.

This procedure should be followed until the coupling losses have been determined between each transmitting antenna which normally operates below 1000 MHz and all of the remaining antennas on the Sabreliner.

Signal Substitution Method

The test equipment configuration to be used for measuring the coupling losses at frequencies above 1000 MHz is shown in Figure II-2.

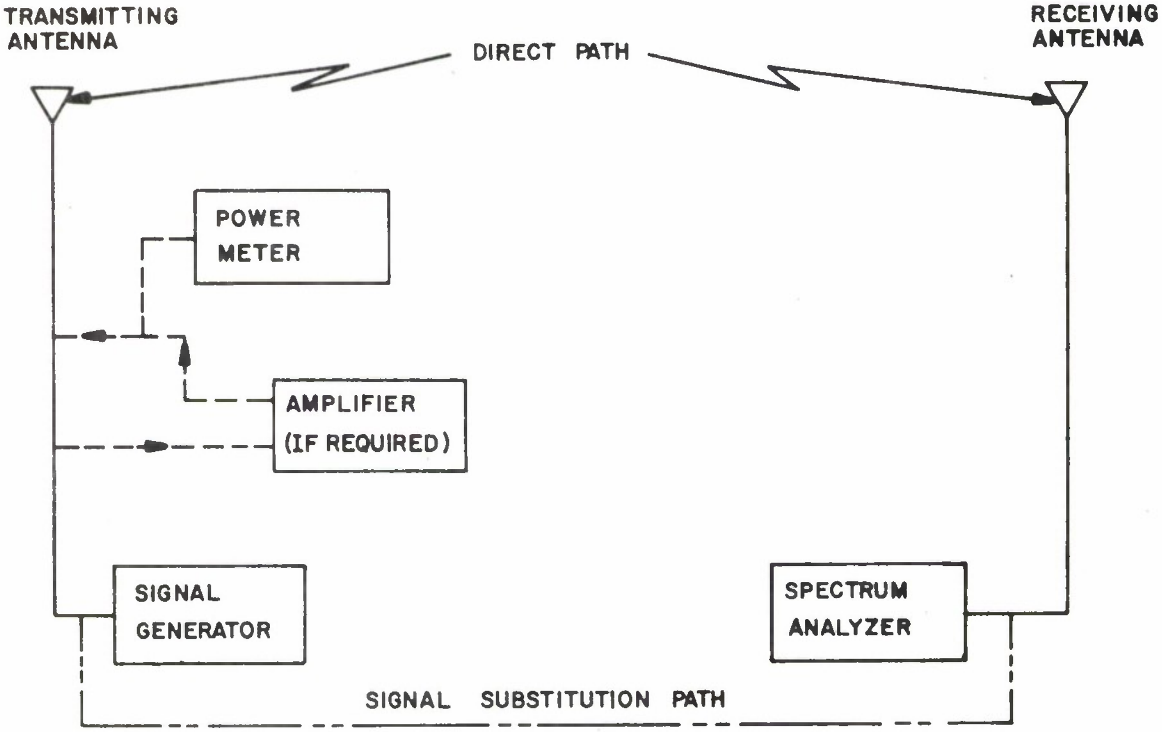


Figure II-2. Equipment Configuration for Measurements Above 1000 MHz.

The types of equipments recommended for use are:

| Frequency Range | Type |
|---|---|
| Signal Generators | |
| 800-2400 MHz | HP-8614A, or equivalent |
| 1800-4500 MHz | HP-8616A, or equivalent |
| 7-11 GHz | HP-620B, or equivalent |
| Spectrum Analyzer | |
| 10 MHz - 40 GHz | 8555A/8552B/141T or equivalent |
| Amplifier (If Required) | |
| 7-11 GHz | HP-495A, or equivalent |
| Power Meter (If Required) | |
| 7-11 GHz | HP434, or equivalent |
| Connectors & Adapters | as required |

In performing the measurements, the following procedures should be followed for each antenna combination to be considered:

1. Disconnect the transmission lines associated with the transmitting and receiving equipments under consideration at the input to the respective equipments and connect them to the test instruments as shown.
2. Tune the signal generator and spectrum analyzer to a frequency within the operating range of the transmitting antenna.
3. Set the attenuator control for the signal generator in its highest position (lower power output).

4. Set the sensitivity control of the analyzer in its mid-range position and the attenuator in its lowest position.

5. Increase the power output of the generator until a clearly visible signal is shown on the spectrum analyzer display and record the output power of the generator in dBm as well as the reference level to be used with the analyzer.

6. Decrease the generator output signal to a minimum level (maximum attenuation).

7. Disconnect the test equipment from the Sabreliner transmission lines and connect the signal generator directly to the spectrum analyzer through a short piece of transmission line as indicated for the signal substitution path in the figure.

8. Increase the power output of the signal generator until the visible signal to the analyzer is at an identical level to that previously recorded.

9. Record the output level of the generator in dBm.

10. The coupling loss is equal to the algebraic difference in dBm, between the output power recorded for the direct path and the output power recorded for the substitution path.

11. Repeat the measurement four additional times at different frequencies within the operating range of the transmitter.

12. Reverse the antenna connections and perform the measurements five additional times on the operating frequencies previously used.

13. Repeat the procedure for each transmitting antenna with an operating frequency above 1000 MHz.

### Special Procedures for 7-11 GHz Substitution Measurements

When the operating frequency is between 7-11 GHz, it may be necessary to further amplify the signal generator output to obtain a usable direct path signal on the spectrum analyzer display. If this becomes necessary the following procedures apply:

1. Insert the amplifier between the signal generator and transmitting antenna as shown by the dashed lines in Figure II-2.
2. Increase the power of the signal generator until a usable signal is observed on the analyzer.
3. Record the output power indicated on the signal generator.
4. Reduce the output level of the signal generator and substitute the power meter for the transmitting antenna.
5. Increase the output level of the signal generator to the level recorded in 3.
6. Record the amplifier output level as indicated by the power meter.

7. Disconnect the signal generator from the amplifier, disconnect the analyzer from the receiving antenna, and connect the test instruments to each other as shown in the figure as the substitution path.

8. Perform Steps 8 - 13 as described in the previous procedures.

### Precautions to be Followed

It is desirable that these measurements be made while the Sabreliner is in flight to minimize perturbations due to objects in the physical environment. In addition, all of the transmitting equipment installed on the airplane should be de-energized for these tests to prevent contamination of the measurements by undesired signals. It is recognized, however, that these two options may be mutually exclusive. Since the second factor is obviously more important in terms of potential effects on the observed data and more easily achieved from a logistical point of view, it appears satisfactory to perform the measurements while the aircraft is on the ground. Nevertheless, the aircraft should be in an area which is as clear as possible with respect to nearby metal objects, and the test frequencies chosen should be separated as far as is feasible from the frequencies in use by the nearby operational equipments.

Finally, although Figure 3-3 of this report contains no coupling loss predictions involving the HF long wire antenna on the Sabreliner, the measured value of the losses between the HF antenna and other antennas on the aircraft should be obtained. Further, the losses should be obtained on at least five operating frequencies within the HF range.

# APPENDIX III

## FREQUENCY ANALYSIS SYSTEM (FAS) SUBROUTINE

This Appendix contains the flow diagram and the program listing for the FAS subroutine used to calculate the relative rejection characteristics of receivers. The flow chart is shown in Figure III-1. The program listing, which is written in the FORTRAN V language, is shown in Figure III-2.

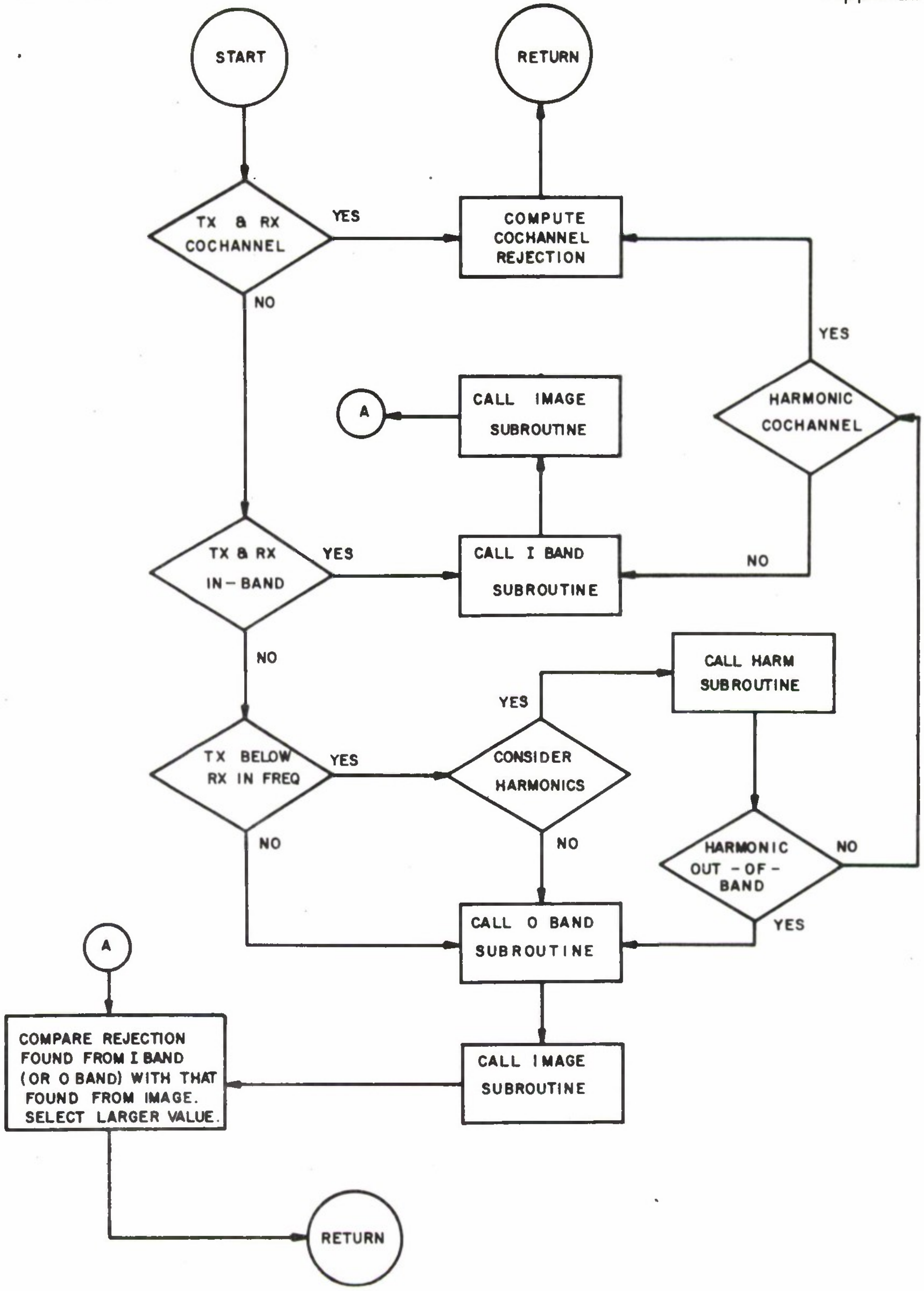


Figure III-1. FAS Flow Chart.

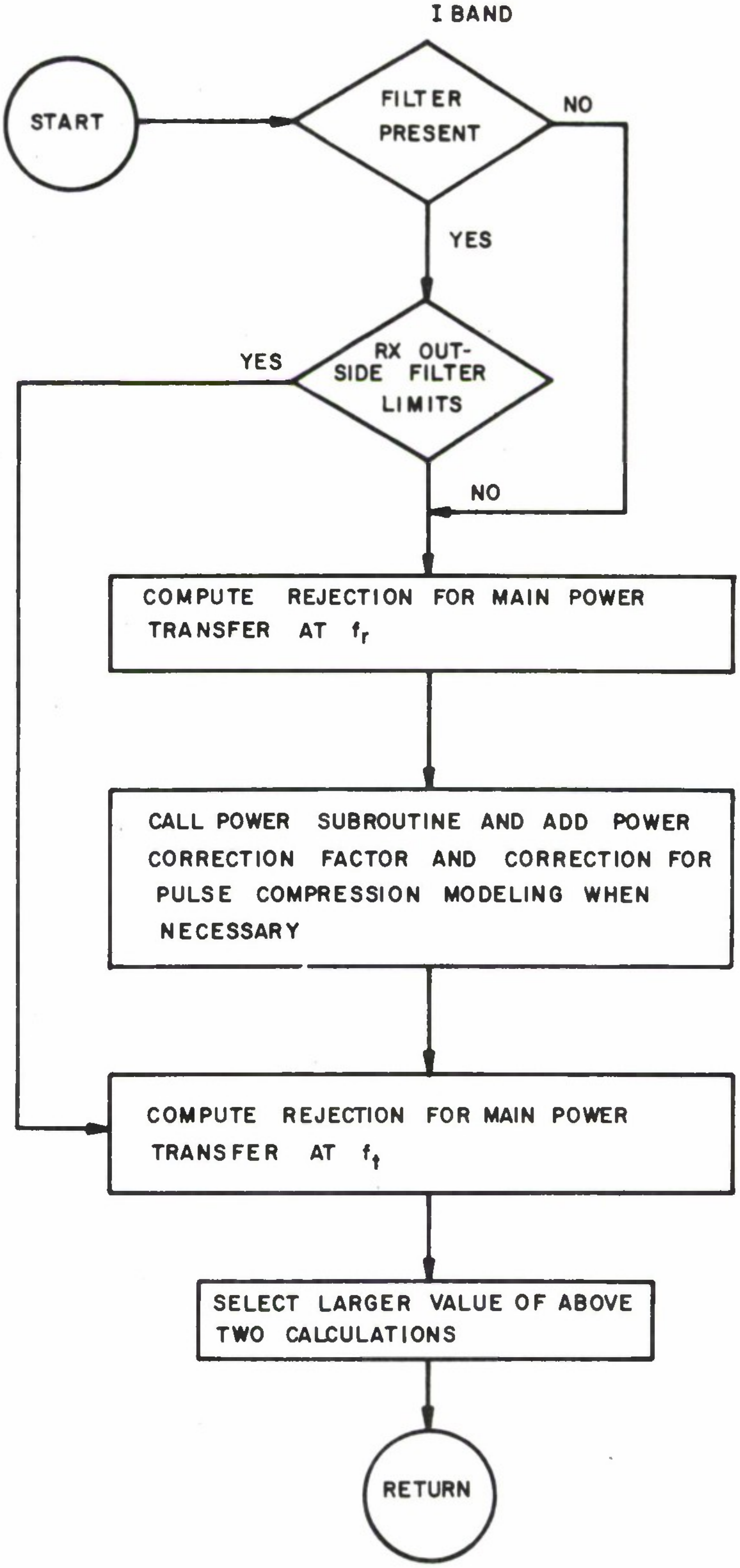


Figure III-1. (Continued).

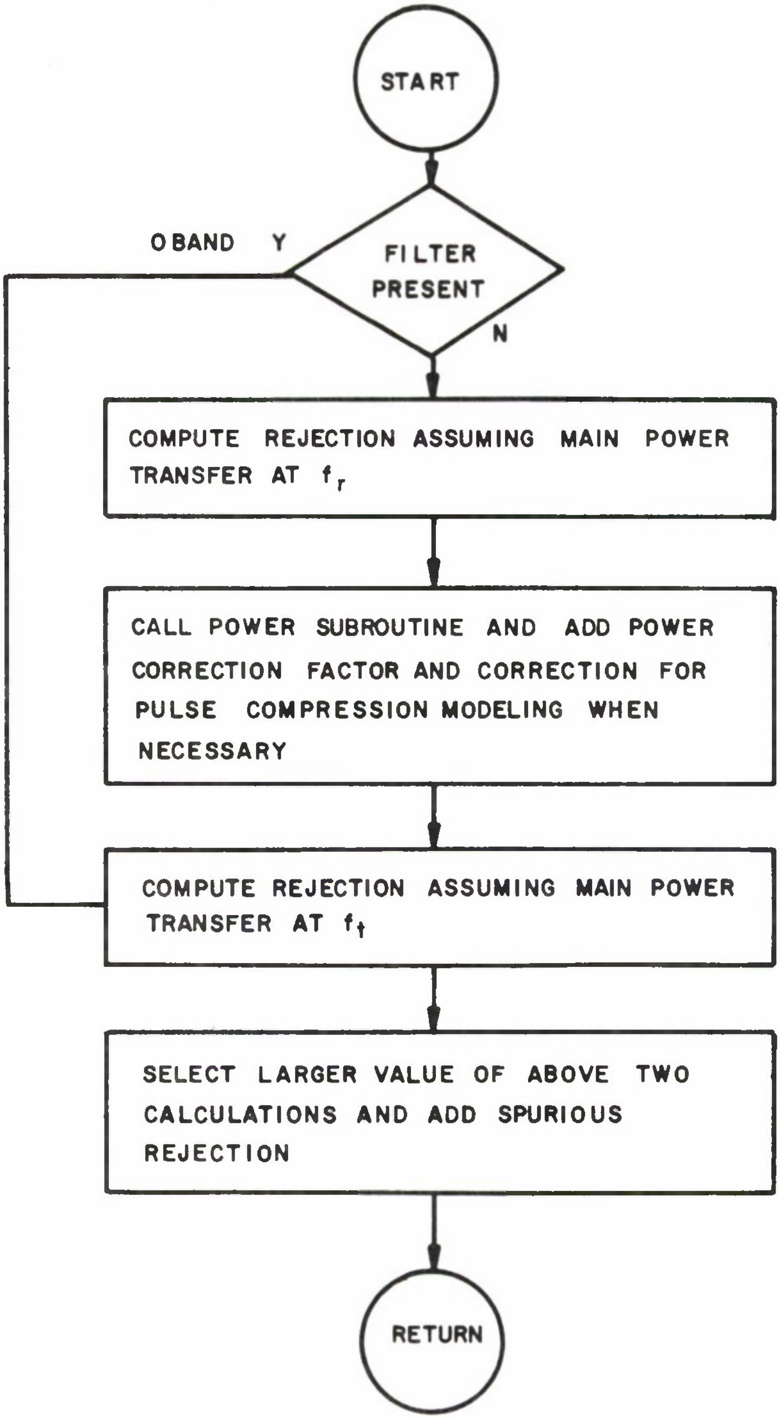


Figure III-1. (Continued)

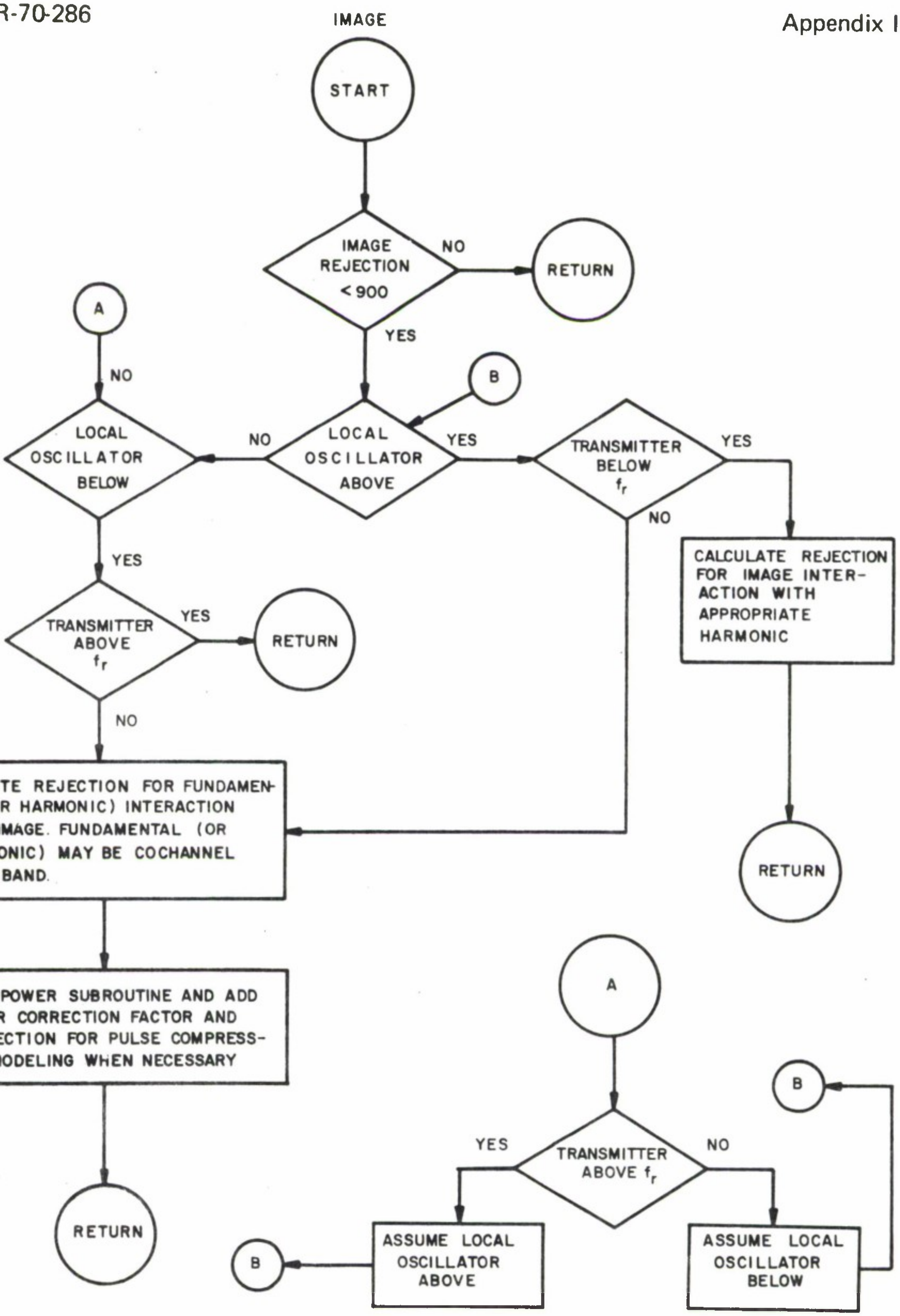


Figure III-1. (Continued).

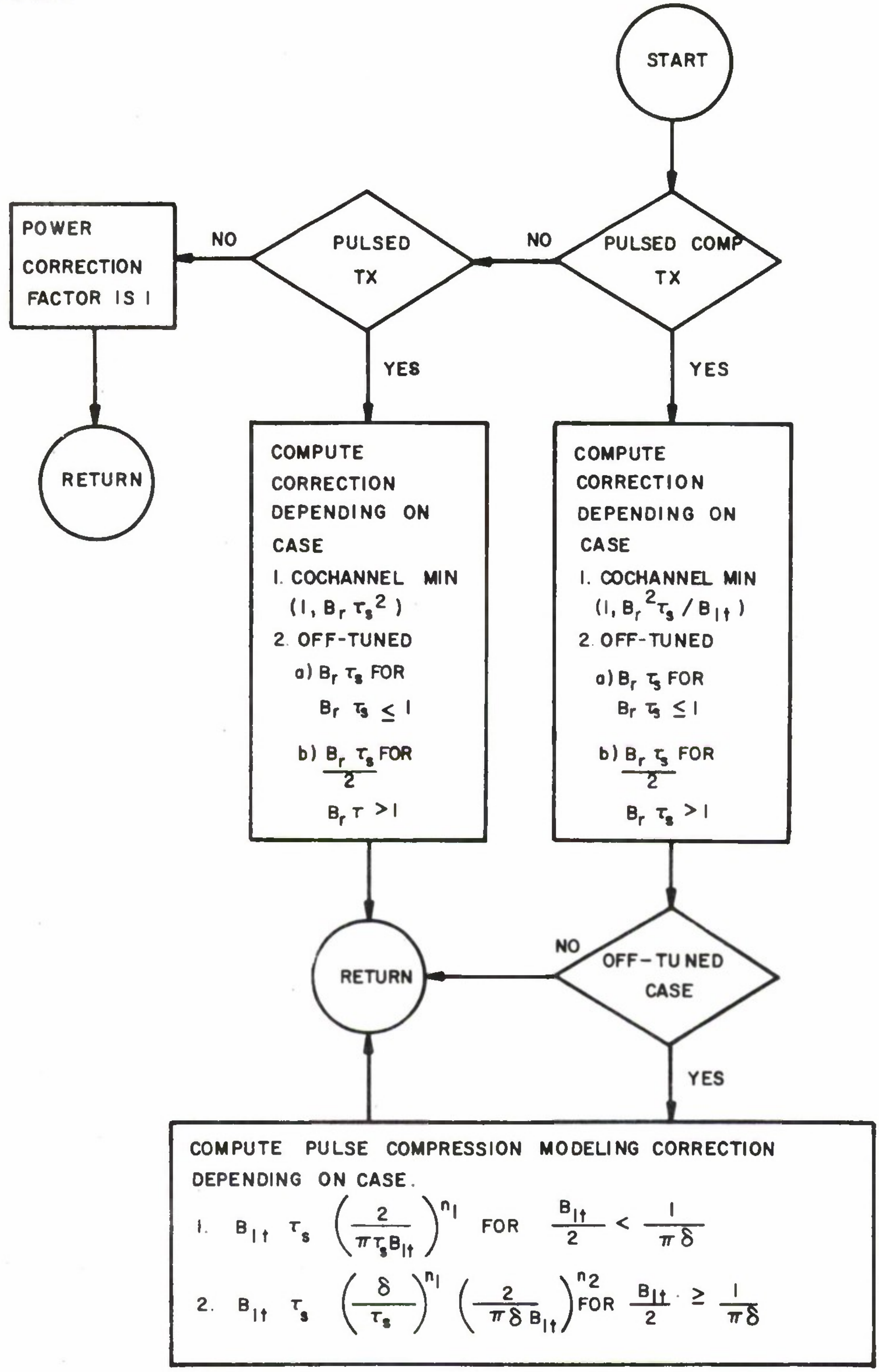


Figure III-1. (Continued).

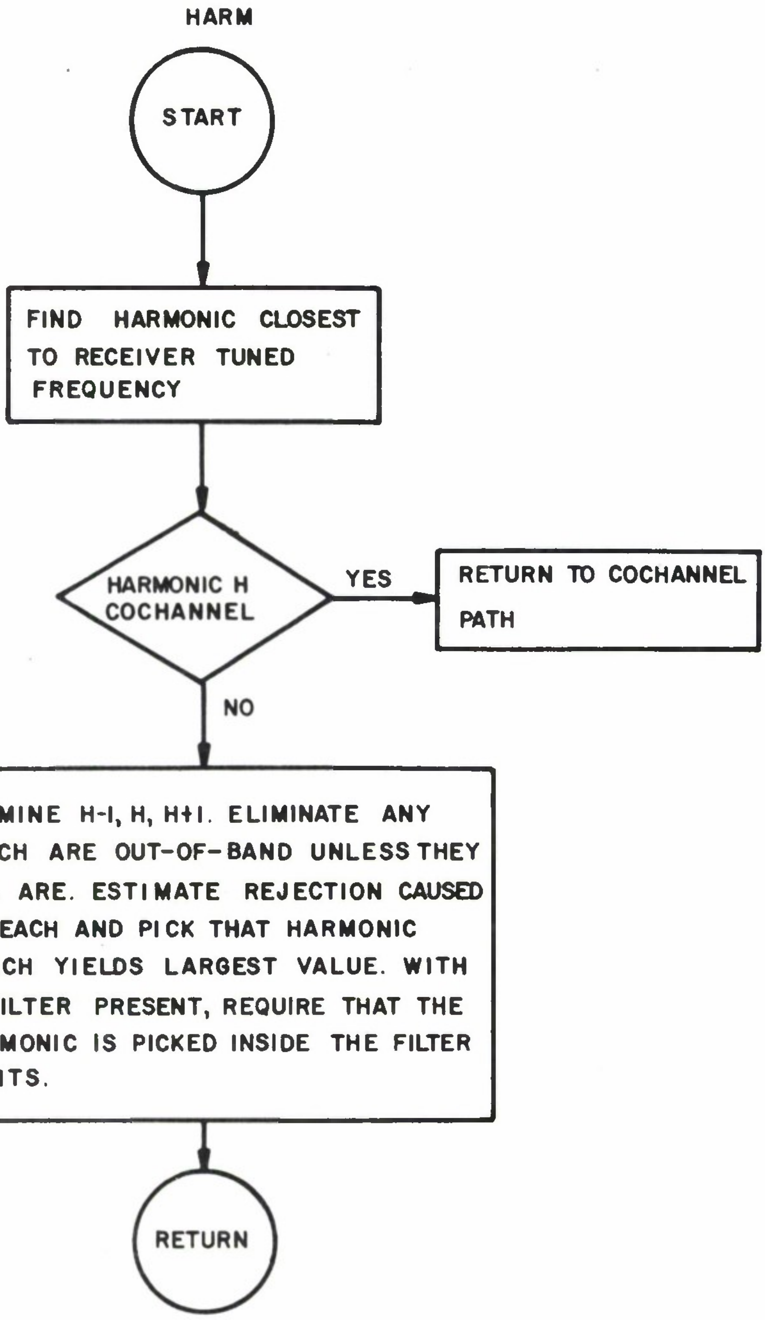


Figure III-1. (Continued).

```
00101    C
00101    C *** THIS SUBROUTINE CALCULATES OFF-FREQUENCY REJECTION
00101    C
00101    C *** INPUT PARAMETERS
00101    C
00101    C *** RECEIVER
00101    C
00101    C *** F1R,F2R - LOWER AND UPPER LIMITS OF TUNED FREQUENCY (MHZ)
00101    C *** FA,FB   - LOWER AND UPPER FREQUENCY CUTOFF FOR SPURIOUS RESPONSE (MHZ)
00101    C *** M1,M2   - FIRST AND SECOND SELECTIVITY SLOPE FALLOFFS (DB/DEC)
00101    C *** BW      - BANDWIDTH (MHZ)
00101    C *** FIF     - INTERMEDIATE FREQUENCY (MHZ)
00101    C *** LOP     - LOCAL OSCILLATON POSITION (A=ABOVE,B=BELOW,C=UNKNOWN)
00101    C *** KI      - IMAGE REJECTION (DB)
00101    C *** KS      - SPURIOUS REJECTION (DB)
00101    C
00101    C *** TRANSMITTER
00101    C
00101    C *** F1T,F2T - LOWER AND UPPER LIMITS OF TUNED FREQUENCY (MHZ)
00101    C *** FC,FO   - LOWER AND UPPER LIMITS OF FILTER (MHZ)
00101    C *** B1T,B2T - FIRST AND SECOND BANDWIDTHS (MHZ)
00101    C *** N1,N2   - FIRST AND SECOND EMISSION SPECTRUM SLOPE FALLOFFS (DB/DEC)
00101    C *** NH      - MAXIMUM HARMONIC NUMBER TO CONSIDER (1 TO 9)
00101    C *** KH(8)   - HARMONIC REJECTION (DB) (UP TO EIGHT DIFFERENT LEVELS ALLOWED)
00101    C *** IT36    - MODULATION TYPE
00101    C *** IPCOMP  - PULSE COMPRESSION INDICATOR
00101    C *** TAU     - STRETCHED PULSEWIDTH (USEC)
00101    C *** PRT     - PULSE RISE TIME (USEC)
00101    C
00103          REAL M1,KI,KS,M2,N1,KN,N2,LF,LF1,LF2,LF3
00104          INTEGER W,CCHNL
00105          COMMON/RBLOCK/A(32),FIF,BW,B(2),M1,F1R,F2R,KI,KS,LOP,C,F1,D(3),M2,
00105         *E(17),FA,FB,RBL(140)
00106          COMMON/TBLOCK/W(33),B1T,FIL1,IT36,N1,F1T,F2T,KH(8),N2,G(3),PRT,
00106         *GG(2),TAU,R(3),IPCOMP,FC,FO,RH(9),B2T,NH,TBL(19)
00107          COMMON/PBLOCK/AA(19),LF,BB(2),W,PBL(37)
00107    C *** THIS COMMON BLOCK IS GENERATED BY OFR
00110          COMMON/ZBLOCK/CCHNL,PC,LF1,LF2,LF3,OF,OFS,BW,IMAG,F1P,F2P,OF1,OF2,
00110         *OF3,OF4,OF5,OF6,OFFIL1,OFFIL2,P1
00111          DATA PI/3.14159/,IC/1HC/
00114          P1=N1/10.
00115          IF(IPCOMP.EQ.IC) GO TO 1
00117          GO TO 3
00120        1 IF(B1T/2.LT.1/(PI*PRT)) GO TO 3
00122          N1=N2
00123        3 IMAG=0
00124          W=1
00125          CCHNL=0
00126          N1=N1/10
00127          N2=N2/10
00130          M1=M1/10
00131          M2=M2/10
00132          OF1=F1T-F2R
00133          OF2=F1R-F2T
00134          BW=AMAX1(B1T,BW)
```

Figure III-2. FAS Program Listing.

```
00135             F1H=F1R
00136             F2H=F2R
00137             OFFIL1=F1T-FC
00140             OFFIL2=FD-F2T
00141             IF(DF1-0.)80,80,81
00144          80 IF(DF2-0.)20,20,81
00147          81 IF(F1T.GT.FB+B2T/2)GO TO 10
00151             IF (F2T.LT.FA-B2T/2) GO TO 10
00153             GO TO 30
00153       C *** TRANSMITTER TUNED OUTSIDE OF RECEIVER TUNING RANGE R, WHERE
00153       C ***            FA-B2T/2 < R < FB+B2T/2
00154          10 IF(DF2-(B2T+BR)/2) 12,11,11
00157          12 IF(DF1.LT.(B2T+BR)/2) GO TO 60
00157       C *** TRANSMITTER TUNED ABOVE RECEIVER
00161             DF=DF1
00162             DFS=FB-F2R
00163             GO TO 8888
00163       C *** TRANSMITTER TUNED BELOW RECEIVER BY (BR+B2T)/2
00164          11 CALL HARM(B2T)
00165          17 IF(H*F2T.LT.FA-(B2T+BR)/2) GO TO 18
00167             IF(H*F1T.GT.FB+(B2T+BR)/2) GO TO 15
00171             GO TO 7777
00172          16 DFS=FB-F2R
00173             GO TO 8888
00174          15 IF(H-2) 16,16,16
00174       C *** THE SECOND HARMONIC IS OUT OF BAND AND THE FUNDAMENTAL IS EVEN FARTHER
00174       C *** AWAY (I.E. OUTSIDE OF RECEIVER TUNING RANGE)
00177          18 DFS=F1R-FA
00200             GO TO 8888
00200       C *** TRANSMITTER AND RECEIVER ARE COCHANNEL
00201          20 CCHNL=1
00202             CALL POWER
00203             LF=PC
00204          22 IF(H-2)9999,24,24
00207          24 ALFP=LF-KH(H-1)
00210             GO TO 6666
00210       C *** THE TRANSMITTER IS LESS THAN BR/2 AWAY FROM THE RECEIVER TUNING RANGE
00211          60 IF(F1R-FA-(B2T+BR)/2) 65,65,67
00214          67 IF(FB-F2R-(B2T+BR)/2) 65,65,69
00217          69 IF(DF1-0.) 66,66,70
00222          66 DF=DF2
00223             DFS=F1R-FA
00224             GO TO 8888
00225          70 DF=DF1
00226             DFS=FB-F2R
00227             GO TO 8888
00230          65 IF(DF1.GT.0.) GO TO 68
00232             DF=DF2
00233             GO TO 7777
00234          68 DF=DF1
00235             GO TO 7777
00235       C *** THE TRANSMITTER IS WITHIN THE RECEIVER TUNING RANGE
00236          30 IF(DF2.GT.BH/2) GO TO 35
00240             IF(DF1-BH/2)20,20,32
00243          32 DF=DF1
```

Figure III-2. Continued.

```
00244    112.          IF(ABS(DF)-BW/2) 20,20,7777
00244    113.   C *** THE TRANSMITTER IS FAR ENOUGH AWAY FROM THE RECEIVER THAT HARMONICS
00244    114.   C *** MUST AT LEAST BE CONSIDERED AS THE INTERACTION CAUSING OFR TO BE GREATEST
00247    115.       35 CALL HARM(S20)
00250    116.          GO TO 7777
00251    117.     6666 HH=H
00252    118.          CALL IMAGE
00253    119.          IF(XLFP-LF3) 6667,6668,6668
00256    120.     6667 LF=LF3
00257    121.          GO TO 9999
00260    122.     6668 H=HH
00261    123.          LF=XLFP
00262    124.          GO TO 9999
00263    125.     7777 CALL IBAND
00264    126.          XLFP=AMAX1(LF1,LF2)
00265    127.          GO TO 6666
00266    128.     8888 CALL DBAND
00267    129.          XLFP=AMAX1(LF1,LF2)
00270    130.          GO TO 6666
00271    131.     9999 N1=10*N1
00272    132.          N2=10*N2
00273    133.          M1=10*M1
00274    134.          N2=10*M2
00275    135.          IF(LF.GT.0..AND.BW*TAU.GT.1.) LF=0.
00277    136.          IF(IPCOMP.NE.IC) RETURN
00301    137.          IF(BIT/2.LT.1/(PI*PRT)) RETURN
00303    138.          N1=PI*10.
00304    139.          RETURN
00305    140.          END
```

Figure III-2. Continued.

Figure III-2. Continued.

```
SUBROUTINE QBAND      ENTRY POINT 000325

STORAGE USED (BLOCK, NAME, LENGTH)

      0001    .CODE    000333
      0000    .DATA    000046
      0002    .BLANK   000000
      0003    RBLOCK   000317
      0004    TBLOCK   000320
      0005    PBLOCK   000074
      0006    ZBLOCK   000023


EXTERNAL REFERENCES (BLOCK, NAME)

      0007    INTRUP
      0010    POWER
      0011    NEXP6$
      0012    ALOG10
      0013    NERR3$


STORAGE ASSIGNMENT FOR VARIABLES (BLOCK, TYPE, RELATIVE LOCATION, NAME)

 0001     000304 10L        0001     000263 11L        0001     000144 2L         0001     000307 21L        0001     000171 4L
 0001     000124 6L         0001     000173 7L         0001     000132 9L         0001     000276 9999L      0003     000000 A
 0005     000000 AA         0003     000042 B          0005     000024 BB         0006     000007 BM         0003 R   000041 BR
 0004 R   000041 BIT        0004 R   000101 B2T        0003     000052 C          0006 I   000000 CCMNL      0003     000054 D
 0006 R   000005 OF         0000 R   000000 OFA        0000 R   000001 OFB        0000 R   000002 OFC        0000 R   000003 OFF
 0006 R   000021 OFFIL1     0006 R   000022 OFFIL2     0000 R   000004 OFG        0006 R   000006 OFS        0006 R   000013 OF1
 0006 R   000014 OF2        0006     000015 OF3        0006     000016 OF4        0006     000017 OF5        0006     000020 OF6
 0003     000060 E          0004     000042 F          0003     000101 FA         0003     000102 FB         0004 R   000073 FC
 0004     000074 FD         0003     000053 FI         0003     000040 FIF        0000 R   000007 F1         0006     000011 F1P
 0003     000045 F1R        0004     000045 F1T        0000 R   000013 F12        0000 R   000015 F14        0000 R   000016 F15
 0000 R   000017 F16        0006     000012 F2P        0003     000046 F2R        0004 R   000046 F2T        0000 R   000010 F5
 0000 R   000011 F6         0000 R   000012 F7         0004     000060 G          0004     000064 GG         0005 I   000026 H
 0000 I   000005 I          0006     000010 IMAGL      0000     000030 INJPS      0004     000072 IPCOMP     0004     000043 IT36
 0000 I   000006 J          0004 R   000047 KM         0003 R   000047 K1         0003 R   000050 KS         0005 R   000023 LF
 0006 R   000002 LF1        0006 R   000003 LF2        0006 R   000004 LF3        0003     000051 LOP        0003 R   000044 M1
 0003 R   000057 M2         0004 R   000044 N1         0004     000102 N11        0004 R   000057 N2         0005     000027 PBL
 0006 R   000001 PC         0004     000063 PRT        0004     000000 Q          0004     000067 R          0003     000103 RBL
 0004     000075 RR         0004     000066 TAU        0004     000103 TBL        0000 R   000014 Z          0000 R   000020 ZZ


00101      1*        SUBROUTINE QBAND
00103      2*        REAL M1,K1,KS,M2,N1,KM,N2,LF,LF1,LF2,LF3
```

Figure III-2. Continued.

```
00101            SUBROUTINE IRAD
00103            REAL M1,K1,KS,M2,N1,KM,N2,LF,LF1,LF2,LF3
00104            INTEGER CCHNL
00105            INTEGER M
00106            COMMON/RBLOCK/A(32),F1F,BR,B(2),M1,F1R,F2R,K1,KS,LOP,C,F1,D(3),M2,
00106           *E(17),FA,FB,RBL(140)
00107            COMMON/TBLOCK/G(33),B1T,F(1),IT36,N1,F1T,F2T,KM(8),N2,W(3),PNT,
00107           *GG(2),TAU,R(3),IPCOMP,FC,FD,RN(4),B2T,N11,TBL(14)
00110            COMMON/PBLOCK/AA(19),LF,BB(2),M,PBL(37)
00110      C *** THIS COMMON BLOCK IS GENERATED BY OFR
00111            COMMON/ZBLOCK/CCHNL,PC,LF1,LF2,LF3,OF,OF5,KM,IMAGE,F1F,F2P,OF1,
00111           *OF2,OF3,OF4,OF5,OF6,OFFIL1,OFFIL2
00112            CCHNL=0
00113            CALL INTRUP(I,J,$10)
00114            OF=ABS(OF)
00115            OFA=ABS(OF-BR/2)
00116            OFB=B2T/2
00117            OFC=OF+BR/2
00120            OFD=OF+B1T/2
00121            OFE=ABS(OF-B1T/2)
00122            F1=1/B1T
00123            F2=1/(N1-1)
00124            F3= ((B1T/(2*OFD))**N1)*OFD
00125            IF (OF.LT.(BR+B1T)/2) GO TO 1000
00127            F4= ((B1T/(2*OFA))**N1)*OFA
00130            F9= ((BR/(2*OFE))**M1)*OFE
00131            CF=0.
00132            GO TO 1001
00132      C *** THE TRANSMITTER AND RECEIVER ARE NOT CO-CHANNEL, BUT LARGE BANDWIDTHS
00132      C *** CAUSE THE EMISSION SPECTRUM AND SELECTIVITY CURVES TO OVERLAP, WHICH
00132      C *** NECESSITATES CORRECTIONS TO THE OFR INTEGRAL
00133       1000 F4=B1T/2
00134            F9=BR/2
00135            CF= ((B1T+BR)/2 - OF)* F1
00136       1001 F5=(B1T/B2T)**N1
00137            F6=1/(N2-1)
00140            F7= ((OFB/OFC)**N2)*OFC
00141            F8= OFB
00142            F12=((B2T/(2*OFA))**N2)*OFA
00143            F13=((B1T/(2*OFC))**N1)*OFC
00143      C *** IF THE RECEIVER TUNED FREQUENCY LIES OUTSIDE THE FILTER LIMITS,
00143      C *** NO CALCULATION FOR MAXIMUM POWER TRANSFER AT THE RECEIVER TUNED
00143      C *** FREQUENCY IS MADE (FILTER IS ASSUMED IDEAL)
00144            IF(FC-0)89,89,79
00147         79 IF(M.NE.1) GO TO 84
00151            IF(ABS(OF1)-ABS(OF2)) 83,83,81
00154         83 IF(ABS(OF1)-OFFIL1) 89,31,31
00157         81 IF(ABS(OF2)-OFFIL2) 89,31,31
00162         84 IF((M-1)*F2T.GT.OFFIL2) GO TO 31
00164         89 IF(OF-(BR+B2T)/2) 92,90,90
00167         92 IF(OFB-OFC)93,91,91
00172         93 Z=F1 * (( F4 - F3 ) * F2 + F5 * F6 * ( F8 - F7 ))
00173         99 Z = Z + CF
00174            IF (Z - 0.) 10,10,999
```

Figure III-2. Continued.

```
00174  C *** THE RECEIVER 'BOXCAR' INTERSECTS THE TRANSMITTER EMISSION SPECTRUM
00174  C *** ON BOTH SLOPES (MAXIMUM POWER TRANSFER AT RECEIVER TUNED FREQUENCY)
00177    999 LF1 = 10 * ALOG10(Z)
00200     30 CALL POWER
00201        LF1=LF1+PC
00202        GO TO 32
00203     31 LF1=-999.
00204     32 CALL INTRUP(1,J,520)
00205        F10=((BR/(2*DFU))**M1)*DFO
00206        F11=1/(M1-1)
00207        Z2 = F1 * F11 * ( F9 - F10 )
00210        Z2 = Z2 + CF
00211        IF (Z2 - 0.) 20,20,200
00211  C *** THE TRANSMITTER 'BOXCAR' INTERSECTS THE RECEIVER SELECTIVITY CURVE
00211  C *** EITHER ON THE FIRST SLOPE OR AT THE SPURIOUS LEVEL (MAXIMUM POWER AT
00211  C *** TRANSMITTER TUNED FREQUENCY)
00214    200 LF2=10*ALOG10(Z2)
00215     40 IF(IMAGE.EQ.1) RETURN
00215  C *** THE FOLLOWING THREE STATEMENTS COMPENSATE FOR A COMPILER ERROR
00217        KS=-KS
00220        CCHNL=1
00221        CALL POWER
00222        KSP=KS+PC
00223        CCHNL=0
00224        LF2=AMAX1(LF2,KSP)
00225        KS=-KS
00226        IF(N-2)9999,60,80
00231     80 LF1=LF1-KM(N-1)
00232        LF2=LF2-KM(N-1)
00233   9999 CALL INTRUP(1)
00234        RETURN
00234  C *** RECEIVER 'BOXCAR' INTERSECTS TRANSMITTER EMISSION SPECTRUM ON THE
00234  C *** SECOND SLOPE FALLOFF (MAXIMUM POWER TRANSFER AT RECEIVER TUNED FREQUENCY)
00235     90 Z= F1 * F5 * F6 * ( F12 - F7 )
00236        GO TO 99
00236  C *** RECEIVER 'BOXCAR' INTERSECTS TRANSMITTER EMISSION SPECTRUM ON THE
00236  C *** FIRST  SLOPE FALLOFF (MAXIMUM POWER TRANSFER AT RECEIVER TUNED FREQUENCY)
00237     91 Z= F1 * F2 * ( F4 - F13 )
00240        GO TO 99
00241     10 LF1 = -400.
00242        GO TO 30
00243     20 LF2= -400.
00244        GO TO 40
00245        END
```

Figure III-2. Continued.

```
SUBROUTINE TRANO      ENTRY POINT 000510

STORAGE USED (BLOCK, NAME, LENGTH)

        0001    *CODE    000520
        0000    *DATA    000061
        0002    *BLANK   000000
        0003    RBLOCK   000317
        0004    TBLOCK   000320
        0005    PBLOCK   000074
        0006    ZBLOCK   000023


EXTERNAL REFERENCES (BLOCK, NAME)

        0007    INTRUP
        0010    POWER
        0011    NEXP6$
        0012    ALOG10
        0013    NERR3$


STORAGE ASSIGNMENT FOR VARIABLES (BLOCK, TYPE, RELATIVE LOCATION, NAME)

 0001     000465 10L        0001     000114 1000L      0001     000130 1001L      0001     000470 20L        0001     000313 30L
 0001     000321 31L        0001     000323 32L        0001     000366 40L        0001     000231 81L        0001     000237 84L
 0001     000251 89L        0001     000446 90L        0001     000456 91L        0001     000300 99L        0001     000490 9999L
 0003     000000 A          0005     000000 AA         0003     000042 B          0005     000024 BB         0006     000007 BM
 0003 R   000041 BR         0004 R   000041 BIT        0004 R   000101 B2T        0003     000052 C          0006 I   000000 CCHNL
 0000 R   000014 CF         0003     000054 D          0006 R   000005 OF         0000 R   000002 OFA        0000 R   000003 OFB
 0000 R   000004 OFC        0000 R   000005 OFO        0000 R   000006 OFL        0006 R   000021 OFFIL1     0006 R   000022 OFFIL2
 0006     000006 OFS        0006 R   000013 OF1        0006 R   000014 OF2        0006     000015 OF3        0006     000016 OF4
 0006     000017 OF5        0006     000020 OF6        0003     000060 E          0004     000042 F          0003     000101 FA
 0003     000102 FB         0004 R   000073 FC         0004     000074 FD         0003     000053 F1         0003     000040 FIF
 0000 R   000007 F1         0006     000011 F1P        0003     000045 F1H        0004     000045 F1T        0000 R   000024 F1U
 0000 R   000025 F11        0000 R   000021 F12        0000 R   000022 F13        0000 R   000010 F2         0006     000012 F2P
 0003     000046 F2R        0004 R   000046 F2T        0000 R   000011 F3         0000 R   000012 F4         0000 R   000015 FS
 0000 R   000016 F6         0000 R   000017 F7         0000 R   000020 F8         0000 R   000013 F9         0004     000060 G
 0004     000064 GG         0005 I   000026 H          0000 I   000000 I          0006 I   000010 IMAGE      0000     000037 INJPS
 0004     000072 IPCOMP     0004     000043 I136       0000 I   000001 J          0004 R   000047 KM         0003 R   000047 K1
 0003 R   000050 KS         0000 I   000027 KSP        0005 R   000023 LF         0006 R   000002 LF1        0006 R   000003 LF2
 0006 R   000004 LF3        0003     000051 LOP        0003 R   000044 M1         0003 R   000057 M2         0004 R   000044 N1
 0004     000102 N11        0004 R   000057 K2         0005     000027 PBL        0006 R   000001 PC         0004     000063 PRT
 0004     000000 Q          0004     000067 W          0003     000103 RBL        0004     000075 RR         0004     000066 TAU
 0004     000103 TBL        0000 R   000023 Z          0000 R   000026 ZZ
```

Figure III-2. Continued.

```
00104          INTEGER CCHNL
00105          INTEGER H
00106          COMMON/RBLOCK/A(32),FIF,BR,B(2),M1,F1R,F2R,K1,KS,LOP,C,F1,D(3),M2,
00106         *E(17),FA,FB,RBL(140)
00107          COMMON/TBLOCK/Q(33),BIT,F1T1,IT36,N1,F1T,F2T,KH(8),N2,G(3),PRT,
00107         *GG(2),TAU,R(3),IPCOMP,PC,FO,RR(4),B2T,N11,TBL(141)
00110          COMMON/PBLOCK/AA(19),LF,BB(2),H,PBL(37)
00110    C *** THIS COMMON BLOCK IS GENERATED BY OFN
00111          COMMON/ZBLOCK/CCHNL,PC,LF1,LF2,LF3,OF,OFS,BN,IMAGE,F1P,F2P,OF1,
00111         *OF2,OF3,OF4,OF5,OF6,OFFIL1,OFFIL2
00112          CCHNL=0
00113          OF=ABS(OF)
00114          OFS=ABS(OFS)
00115          OFA=ABS(OF-BR/2)
00116          OFB=B2T/2
00117          OFC=OF+BR/2
00120          OFF=OF+B1T/2
00121          OFG=ABS(OF-B1T/2)
00122          CALL INTRUP(I,J,$10)
00123          F1=1/B1T
00124          F5=(B1T/B2T)**N1
00125          F6=1/(N2-1)
00126          F7= ((OFB/OFC)**N2)*OFC
00127          F12=((B2T/(2*OFA))**N2)*OFA
00127    C *** IF THE RECEIVER TUNED FREQUENCY LIES OUTSIDE THE FILTER LIMITS,
00127    C *** NO CALCULATION FOR MAXIMUM POWER TRANSFER AT THE RECEIVER TUNED
00127    C *** FREQUENCY IS MADE (FILTER IS ASSUMED IDEAL)
00130          IF(FC-0)2,2,1
00133        1 IF(H.NE.1)GO TO 9
00135          IF(ABS(OF1)-ABS(OF2)) 5,5,6
00140        5 IF(ABS(OF1)-OFFIL1) 2,4,4
00143        6 IF(ABS(OF2)-OFFIL2) 2,4,4
00146        9 IF((H-1)*F2T.GT.OFFIL2) GO TO 4
00146    C *** RECEIVER 'BOXCAR' INTERSECTS TRANSMITTER EMISSION SPECTRUM ON THE
00146    C *** SECOND SLOPE FALLOFF (MAXIMUM POWER TRANSFER AT RECEIVER TUNED FREQUENCY)
00150        2 Z= F1 * F5 * F6 * ( F12 - F7 )
00151          IF(Z - 0.) 10,10,3
00154        3 LF1=10*ALOG10(Z)
00155          CALL POWER
00156          LF1=LF1+PC
00157          GO TO 7
00160        4 LF1=-999.
00161        7 CALL INTRUP(I,J,$20)
00162          F14=1/(N2-1)
00163          F15=(OFS/OFG)**N2*OFG
00164          F16=(OFS/OFF)**N2*OFF
00164    C *** THE TRANSMITTER 'BOXCAR' INTERSECTS THE RECEIVER SELECTIVITY CURVE
00164    C *** ON THE SECOND SLOPE (MAXIMUM POWER TRANSFER AT THE TRANSMITTER TUNED FREQ)
00165          ZZ=F1 * F14 * ( F15 - F16 )
00166          IF(ZZ - 0.) 20,20,8
00171        8 LF2=10*ALOG10(ZZ)-KS
00172          IF(BR.LT.B1T) LF2=LF2+10*ALOG10(BN/B1T)
00174       11 IF(H-2) 9999,80,80
00177       80 LF1=LF1-KH(H-1)
00200          LF2=LF2-KH(H-1)
00201     9999 CALL INTRUP(I)
00202          RETURN
00203       10 LF1=-400.
00204          GO TO 7
00205       20 LF2=-400.
00206          GO TO 11
00207          END
```

Figure III-2.    Continued.

```
SUBROUTINE IMAGE      ENTRY POINT 000512

STORAGE USED (BLOCK, NAME, LENGTH)

       0001    *CODE    000515
       0000    *DATA    000024
       0002    *BLANK   000000
       0003    RBLOCK   000317
       0004    TBLOCK   000320
       0005    PBLOCK   000074
       0006    ZBLOCK   000023


EXTERNAL REFERENCES (BLOCK, NAME)

       0007    HARM
       0010    IBAND
       0011    POWER
       0012    NERR6S
       0013    NERR3S


STORAGE ASSIGNMENT FOR VARIABLES (BLOCK, TYPE, RELATIVE LOCATION, NAME)

 0001     000422 10L       0001     000443 12L       0001     000446 13L       0001     000014 2L        0001     000460 20L
 0001     000021 3L        0001     000322 30L       0001     000337 31L       0001     000342 32L       0001     000027 4L
 0001     000345 40L       0001     000352 41L       0001     000361 42L       0001     000364 43L       0001     000371 44L
 0001     000376 45L       0001     000407 46L       0001     000417 47L       0001     000043 5L        0001     000056 6L
 0001     000073 7L        0001     000164 70L       0001     000171 71L       0001     000177 72L       0001     000202 73L
 0001     000215 74L       0001     000232 75L       0001     000263 76L       0001     000314 77L       0001     000124 8L
 0001     000155 9L        0001     000502 999L      0003     000000 A         0005     000000 AA        0003     000042 B
 0005     000024 BB        0006 R   000007 BM        0003     000041 BR        0004     000041 BIT       0004     000101 B2T
 0003     000052 C         0006 I   000000 CCHNL     0003     000054 D         0006 R   000005 DF        0006     000021 DFFIL1
 0006     000022 DFFIL2    0000 R   000005 DFH       0006     000006 DFS       0000 R   000004 DFU       0006 N   000013 DF1
 0006 R   000014 DF2       0006     000015 DF3       0006     000016 DF4       0006     000017 DF5       0006     000020 DF6
 0003     000060 E         0004     000042 F         0003     000101 FA        0003     000102 FB        0004     000073 FC
 0004     000074 FD        0003     000053 FI        0003 R   000040 FIF       0006 R   000011 FIP       0003 R   000045 FIR
 0004 R   000045 FIT       0006 R   000012 F2P       0003 R   000046 F2R       0004 R   000046 F2T       0004     000060 G
 0004     000064 GG        0005 I   000026 H         0000 I   000000 IA        0000 I   000001 IB        0000 I   000002 IC
 0006 I   000010 IMAGE     0000     000013 INJPS     0004     000072 IPCOMP    0004     000043 IT36      0004 R   000047 KM
 0003 R   000047 K1        0003 R   000050 KS        0005 R   000023 LF        0006 R   000002 LF1       0006 R   000003 LF2
 0006 R   000004 LF3       0000 I   000003 LOP       0003 I   000051 LOPP      0003 R   000044 M1        0003 R   000067 M2
 0004 R   000044 N1        0004     000102 N11       0004 R   000057 N2        0005     000027 PBL       0006 R   000001 PC
 0004     000063 PRT       0004     000000 Q         0004     000067 R         0003     000103 RBL       0004     000075 RR
 0004     000066 TAU       0004     000103 TBL
```

Figure III-2. Continued.

```
00101      1.          SUBROUTINE IMAGE
00103      2.          REAL M1,K1,KS,M2,N1,KN,N2,LF,LF1,LF2,LF3
00104      3.          INTEGER CCHNL
00105      4.          INTEGER M
00106      5.          COMMON/RBLOCK/A(32),F1,BR,B(2),M1,F1R,F2R,K1,KS,LOPP,C,F1F,O(3),N2
00106      6.         *,E(17),FA,FB,RML(140)
00107      7.          COMMON/TBLOCK/Q(33),BIT,F1(1),IT36,M1,F1T,F2T,KM(8),M2,G(3),PRT,
00107      8.         *GG(2),TAU,R(3),IPCOMP,FC,FO,RH(4),B2T,N11,TBL(141)
00110      9.          COMMON/PBLOCK/AA(19),LF,BB(2),M,PBL(37)
00110     10.    C *** THIS COMMON BLOCK IS GENERATED BY OFR
00111     11.          COMMON/ZBLOCK/CCHNL,PC,LF1,LF2,LF3,OF,OFS,BN,IMAGE,F1P,F2P,OF1,
00111     12.         *OF2,OF3,OF4,OF5,OF6,OFFIL1,OFFIL2
00112     13.          DATA IA/1HA/,IB/1HB/,IC/1HC/
00116     14.          IMAGE=1
00117     15.          M=1
00120     16.          LOP=LOPP
00120     17.    C *** THE USER HAS THE OPTION OF NOT HAVING THE IMAGE INTERACTION
00120     18.    C *** CONSIDERED BY ENTERING A VALUE OF 900 OR GREATER FOR IMAGE REJECTION
00121     19.          IF(K1-900.) 2,1,1
00124     20.        1 LF3=-900.
00125     21.          GO TO 999
00126     22.        2 IF(LOP.EQ.IA)GO TO 3
00130     23.          GO TO 70
00130     24.    C *** IF THE LOCAL OSCILLATOR IS ABOVE THE RECEIVER AND THE TRANSMITTER IS
00130     25.    C *** BELOW, CONSIDER TRANSMITTER HARMONICS' INTERACTION WITH THE IMAGE
00131     26.        3 IF(F2T.LT.F1R) GO TO 4
00133     27.          GO TO 5
00134     28.        4 F1P=F1R+2*F1F
00135     29.          F2P=F2R+2*F1F
00136     30.          CALL HARM(S20)
00137     31.          GO TO 10
00137     32.    C *** IF THE TRANSMITTER IS BELOW THE IMAGE BY MAX(BIT/2,BR/2) THEN
00137     33.    C *** CONSIDER A HARMONIC INTERACTION WITH THE IMAGE
00140     34.        5 IF(F2T+BN/2.LT.F1R+2*F1F) GO TO 6
00142     35.          GO TO 7
00143     36.        6 OFO= F1T-F2R-2*F1F
00144     37.          OFM=2*F1T-F2R-2*F1F
00145     38.          GO TO 40
00145     39.    C *** IS THE LOWER FREQENCY OF THE TRANSMITTER CO-CHANNEL WITH THE IMAGE?
00146     40.        7 IF(F1R+2*F1F-BN/2.GT.F1T.OR.F1T.GT.F2R+2*F1F+BN/2) GO TO 8
00150     41.          GO TO 20
00150     42.    C *** IS THE UPPER FREQENCY OF THE TRANSMITTER CO-CHANNEL WITH THE IMAGE?
00151     43.        8 IF(F1R+2*F1F-BN/2.GT.F2T.OR.F2T.GT.F2R+2*F1F+BN/2) GO TO 9
00153     44.          GO TO 20
00154     45.        9 OF= F1T-F2R-2*F1F
00155     46.          GO TO 10
00156     47.       70 IF(LOP.EQ.IB) GO TO 71
00160     48.          GO TO 30
00160     49.    C *** IF THE LOCAL OSCILLATOR IS BELOW THE RECEIVER AND THE TRANSMITTER IS
00160     50.    C *** ABOVE, SET THE OFR DUE TO AN IMAGE INTERACTION WITH THE TRANSMITTER
00160     51.    C *** FUNDAMENTAL EQUAL TO -400 AND RETURN TO CALLING PROGRAM
00161     52.       71 IF(F1T.GT.F2R) GO TO 72
00163     53.          GO TO 73
00164     54.       72 LF3= -400.
```

Figure III-2. Continued.

```
00165          GO TO 999
001A5    C *** IF THE TRANSMITTER IS BELOW THE IMAGE BY MAX(BIT/2,BW/2) THEN
001A5    C *** CONSIDER A HARMONIC INTERACTION WITH THE IMAGE
00166       73 IF(F2T+BW/2.LT.FIR-2*FIF) GO TO 74
00170          GO TO 75
00171       74 DFU= FIT-F2R+2*FIF
00172          OFH=2*FIT-F2R+2*FIF
00173          GO TO 40
00173    C *** IS THE LOWER FREQUENCY OF THE TRANSMITTER CO-CHANNEL WITH THE IMAGE?
00174       75 IF(FIR-2*FIF-BW/2.GT.FIT.OR.FIT.GT.F2R-2*FIF+BW/2) GO TO 76
0017A          GO TO 20
00176    C *** IS THE UPPER FREQUENCY OF THE TRANSMITTER CO-CHANNEL WITH THE IMAGE?
00177       7A IF(FIR-2*FIF-BW/2.GT.F2T.OR.F2T.GT.F2R-2*FIF+BW/2)GO TO 77
00201          GO TO 20
00202       77 OF= F2R-2*FIF-F2T
00203          GO TO 10
00204       30 IF(FIT.GT.F2R) GO TO 31
00206          IF(F2T.LT.FIR) GO TO 32
00210          RETURN 0
00211       31 LOP=IA
00212          GO TO 5
00213       32 LOP=IB
00214          GO TO 73
00215       40 IF(OFH.GT.0) GO TO 41
00217          GO TO 44
00220       41 IF(OFU.LT.100*OFH) GO TO 42
00222          GO TO 43
00223       42 OF=OFU
00224          GO TO 10
00225       43 OF=OFH
00226          H=2
00227          GO TO 10
00230       44 IF(LOP.EQ.IA)GO TO 45
00232          GO TO 46
00233       45 FIP= FIR+2*FIF
00234          F2P= F2R+2*FIF
00235          GO TO 47
00236       46 FIP= FIR-2*FIF
00237          F2P= F2R-2*FIF
00240       47 CALL HARM(B20)
00241       10 OF1=FIT-F2P
00242          OF2=FIP-F2T
00243          CALL IBAND
00244          IF(LF2-LF1) 11,12,12
00247       11 LF3=LF1-K1
00250          GO TO 13
00251       12 LF3=LF2-K1
00252       13 IF(H.LT.2) GO TO 999
00254          LF3=LF3-KH(H-1)
00255          GO TO 999
00255    C *** CO-CHANNEL PATH
00256       20 CCHNL=1
00257          LF3=-K1
00260          CALL POWER
00261          LF3=LF3+PC
002A2          IF(H.LT.2)GO TO 999
00264          LF3=LF3-KH(H-1)
00265      999 RETURN
0026A          END
```

Figure III-2. Continued.

```
SUBROUTINE HARM       ENTRY POINT 001041

STORAGE USED (BLOCK, NAME, LENGTH)

      0001   *CODE    001054
      0000   *DATA    000132
      0002   *BLANK   000000
      0003   RBLOCK   000317
      0004   TBLOCK   000320
      0005   PBLOCK   000074
      0006   ZBLOCK   000023


EXTERNAL REFERENCES (BLOCK, NAME)

      0007   ALO61U
      0010   NERR6$
      0011   NERR4$
      0012   NERR3$


STORAGE ASSIGNMENT FOR VARIABLES (BLOCK, TYPE, RELATIVE LOCATION, NAME)

 0001    000010 10L       0001    001007 1000L      0001    000022 11L        0001    000030 1250       0001    000050 130G
 0001    000113 14L       0001    000077 1466       0001    000127 15L        0001    000164 16L        0001    000221 17L
 0001    000243 18L       0001    000266 19L        0001    000300 20L        0001    000606 200L       0001    000303 2206
 0001    000311 2266      0001    000375 23L        0001    000330 2356       0001    000503 24L        0001    000347 2406
 0001    000513 25L       0001    000521 26L        0001    000555 27L        0001    000571 28L        0001    000615 29L
 0001    000643 30L       0001    000411 300L       0001    000721 31L        0001    000735 3576       0001    000040 5L
 0001    000752 996L      0001    000725 999L       0003    000000 A          0005    000000 AA         0003    000042 B
 0005    000024 BB        0006 R  000007 BM         0003    000041 BR         0004    000041 BIT        0004    000101 BZT
 0003    000052 C         0000 R  000072 CAL1       0000 R  000073 CAL2       0000 R  000074 CAL3       0006 I  000000 CCMNL
 0003    000054 D         0000 R  000035 DEL1       0000 R  000050 DEL2       0006 R  000005 DP         0006    000021 DFFIL1
 0006 R  000022 DFFIL2    0000 R  000024 DFN        0006    000006 DFS        0006 R  000013 DP1        0006 R  000014 DF2
 0006    000015 DF3       0006    000016 DF4        0006    000017 DF5        0006    000020 DP6        0000 R  000067 D1
 0000 R  000070 D2        0000 R  000071 D3         0003    000060 E          0004    000042 F          0003 R  000101 FA
 0003 R  000102 FB        0004 R  000073 FC         0004    000074 FD         0003    000053 FI         0003    000040 FIP
 0006 R  000011 F1P       0003    000045 F1R        0004 R  000045 F1T        0006 R  000012 F2P        0003    000046 F2R
 0004 R  000046 F2T       0004    000060 G          0004    000064 GG         0005 1  000026 H          0000 R  000000 HAR
 0000 I  000062 I         0000 I  000012 IB         0000 I  000066 ILIM       0006    000010 IMAGE      0000 .  000107 INDP3
 0004    000072 IPCOMP    0004    000043 IT36       0000 1  000075 I1         0000 I  000076 I2         0000 I  000063 J
 0000 I  000064 K         0004 R  000047 KH         0003 R  000047 KI         0003 R  000050 KS         0005 R  000023 LP
 0006 R  000002 LF1       0006 R  000003 LF2        0006 R  000004 LF3        0003    000051 LOP        0003 R  000044 M1
 0003 R  000057 M2        0004 R  000044 N1         0004 I  000102 N11        0004 R  000057 N2         0005    000027 PBL
 0006    000001 PC        0004    000061 PRT        0004    000000 Q          0004    000067 R          0003    000103 RBL
 0004    000075 RR        0000 R  000065 SLOPE      0004    000066 TAU        0004    000103 TBL
```

Figure III-2. Continued.

```
00101            SUBROUTINE HARM(S)
00101      C
00101      C *** NOTE : RETURN 1 GOES TO THE COCHANNEL PATH OF THE CALLING ROUTINE
00101      C
00103            DIMENSION HAR(10),IB(10)
00104            REAL M1,K1,KS,M2,N1,KH,N2,LF,LF1,LF2,LF3
00105            INTEGER CCHNL
00106            INTEGER H
00107            COMMON/RBLOCK/A(32),FIF,BR,B(2),M1,F1R,F2R,KI,KS,LOP,C,FI,D(3),M2,
00107           *E(17),FA,FB,RBL(140)
00110            COMMON/TBLOCK/Q(33),B1T,F(1),IT36,N1,F1T,F2T,KH(8),N2,B(3),PRT,
00110           *GG(2),TAU,R(3),IPCOMP,FC,FD,RR(4),B2T,N11,TBL(141)
00111            COMMON/PBLOCK/AA(19),LF,BB(2),H,PBL(37)
00111      C *** THIS COMMON BLOCK IS GENERATED BY DFR
00112            COMMON/ZBLOCK/CCHNL,PC,LF1,LF2,LF3,DF,DFS,BM,IMAGE,F1P,F2P,DF1,
00112           *DF2,DF3,DF4,DF5,DF6,DFFIL1,DFFIL2
00113            DIMENSION DFN(10),DEL1(10),DEL2(10)
00114            IF(N11-1) 10,10,11
00117         10 DF=AMIN1(ABS(DF1),ABS(DF2))
00120            RETURN
00121         11 IF(FC-0.) 8,8,6
00124          6 DO 7 I=2,N11
00127            IF((I-1)*F2T-DFFIL2) 8,8,7
00132          7 CONTINUE
00134            GO TO 10
00135          8 DO 9 I=1,10
00140            DFN(I)=I*F2T-F1P
00141            DEL1(I)=I*F1T-F2P
00142            DEL2(I)=F1P-I*F2T
00143          9 CONTINUE
00145            DO 13 I=2,N11
00150            IF(DFN(I)-0.) 13,14,14
00153         13 CONTINUE
00153      C *** THE MAXIMUM NUMBER OF HARMONICS TO CONSIDER HAS BEEN REACHED
00155            DF=ABS(DEL2(N11))
00156            H=N11
00157            GO TO 20
00157      C *** THE FOLLOWING IS A COARSE CO-CHANNEL TEST
00160         14 IF(DEL1(I).GT.0.)GO TO 15
00162            H=1
00163            CCHNL=1
00164            GO TO 999
00164      C *** THIS IS A MORE REFINED TEST TO SEE IF THE LOWER END OF THE TRANSMITTER
00164      C *** HARMONIC IS COCHANNEL WITH THE RECEIVER (OR IMAGE)
00165         15 IF(F1P-BM/2.GT.I*F1T.OR.I*F1T.GT.F2P+BM/2) GO TO 16
00167            H=1
00170            CCHNL=1
00171            GO TO 999
00171      C *** THIS IS A MORE REFINED TEST TO SEE IF THE UPPER END OF THE TRANSMITTER
00171      C *** HARMONIC IS COCHANNEL WITH THE RECEIVER (OR IMAGE)
00172         16 IF(F1P-BM/2.GT.I*F2T.OR.I*F2T.GT.F2P+BM/2) GO TO 17
00174            H=I
00175            CCHNL=1
```

```
00176          GO TO 999
00176    C *** ONLE A HARMONIC IS PICKED, THIS TEST DETERMINES WHETHER THE NEXT LOWEST
00176    C *** HARMONIC IS CLOSER TO THE RECEIVER (OR IMAGE)
00177       17 IF(DEL1(I).GT.ABS(DEL2(I-1)))GO TO 18
00201          DF=DEL1(I)
00202          H=I
00203          IF(H.EQ.I) GO TO 999
00205          GO TO 20
00205    C *** IF THE NEXT LOWER HARMONIC IS CLOSER, IS IT ALSO CO-CHANNEL?
00206       18 IF(F1P-BM/2.GT.(I-1)*F2T) GO TO 19
00210          H=I-1
00211          CCHNL=1
00212          GO TO 999
00213       19 DF=DEL2(I-1)
00214          H=I-1
00215          IF(H.EQ.1) GO TO 999
00215    C *** AN HARMONIC H HAS BEEN PICKED. THE FOLLOWING CODING IS DESIGNED TO
00215    C *** REMOVE THE ASSUMPTION THAT ALL HARMONIC LEVELS ARE EQUAL BY COMPARING
00215    C *** THE FREQUENCT REJECTION CAUSED BY H-1, H, AND H+1. ANY HARMONIC THAT
00215    C *** IS FOUND TO BE OUT OF BAND IS ELIMINATED FROM FURTHER CONSIDERATION,
00215    C *** REGARDLESS OF ITS LEVEL.
00217       20 DO 21 J=2,N11
00222       21 HAR(J)=KH(J-I)
00224          HAR(1)=0.
00225          DO 22 K=1,10
00230       22 IB(K)=0
00232          SLOPE=AMIN1(N1,M1)
00233          ILIM=N11+1
00234          DO 12 I=ILIM,10
00237          DEL1(I)=10000.
00240          DEL2(I)=10000.
00241       12 HAR(I)=1000.
00243       32 J=H-1
00244          K=H+1
00245          DO 23 I=J,K
00245    C *** THE FOLLOWING TEST DETERMINES WHETHER A HARMONIC IS IN-BAND. IF HARMONIC
00245    C *** N IS IN-BAND, THEN IB(N) IS SET EQUAL TO 1. OTHERWISE IT IS 0.
00250          IF(I*F2T.LT.FA.OR.I*F1T.GT.FB) GO TO 23
00252          IB(I)=1
00253       23 CONTINUE
00255          IF(IB(H-1).EQ.0) GO )O 26
00257          IF(IB(H).EQ.0) GO TO 29
00257    C *** IF THE FOLLOWING TES' IS FALSE, THEN ALL THREE HARMONICS ARE IN-BAND
00261          IF(IB(H+1).EQ.0) GO 'O 30
00263      300 D1=AMIN1(ABS(DEL1(H-1)),ABS(DEL2(H-1)))
00264          D2=AMIN1(ABS(DEL1(H)),ABS(DEL2(H)))
00265          D3=AMIN1(ABS(DEL1(H+1)),ABS(DEL2(H+1)))
00266          CAL1=-HAR(H-1)-10*SLOPE*ALOG10(D1)
00267          CAL2=-HAR(H)-10*SLOPE*ALOG10(D2)
00270          CAL3=-HAR(H+1)-10*SLOPE*ALOG10(D3)
00271          IF(CAL1.LT.CAL2) GO 'O 24
00273          IF(CAL1.LT.CAL3) GO 'O 25
00275          H=H-1
00276          DF=D1
00277          GO TO 999
```

Figure III-2. Continued.

```
00300          24 1F(CAL2.LT.CAL3) GO 'O 25
00302             UF=U2
00303             60 TO 999
00304          25 H=H+1
00305             UF=D3
00306             60 TO 999
00307          26 1F(IB(H+1).EQ.0) GO 'O 27
00311             1F(IB(H).EQ.0) 60 TO 28
00311       C *** BOTH H ANU H+1 ARE 1N-BAND
00313             11=H
00314             12=H+1
00315             U1=AMIN1(ABS(DEL1(H)),ABS(DEL2(H)))
00316             D2=AMIN1(ABS(OEL1(H+1)),ABS(DEL2(H+1)))
00317             60 TO 200
00317       C *** ONLY H 1S 1N-BANO
00320          27 1F(IB(H).NE.0) 60 TO 999
00320       C *** ALL THREE HARMONICS ARE OUT OF BANU.
00322             SLOPE=AMIN1(N2,M2)
00323             60 TO 300
00323       C *** ONLY H+1 1S IN BANO
00324          28 H=H+1
00325             1F(H.GT.N11) H=H-1
00327             UF=AMIN1(ABS(DEL1(H)),ABS(DEL2(H)))
00330             60 TO 999
00330       C *** AN ERROR HAS OCCURREU 1F 1T IS FOUND THAT ONLY H-1 ANU H+1 ARE 1N-BANU.
00331          29 1F(IB(H+1).EQ.1) RETURN 0
00331       C *** ONLY H-1 1S IN-BANO
00333             H=H-1
00334             DF=AMIN1(ABS(DEL1(H-1)),ABS(DEL2(H-1)))
00335             60 TO 999
00335       C *** BOTH H-1 ANU H ARE 1N-BAND
00336          30 11=H
00337             12=H-1
00340             D1=AMIN1(ABS(UEL1(H)),ABS(DEL2(H)))
00341             U2=AMIN1(ABS(DEL1(H-1)),ABS(DEL2(H-1)))
00342         200 CAL1=-HAR(11)-10*SLOPE*ALOG10(O1)
00343             CAL2=-HAR(I2)-10*SLOPE*ALOG10(O2)
00344             1F(CAL1.LT.CAL2) 60 'O 31
00346             H=11
00347             DF=D1
00350             60 TO 999
00351          31 H=I2
00352             UF=02
00353         999 1F(FC-0.) 1000,1000,998
00356         998 UO 997 1=H,1,-1
00361             1F((1-1)*F2T-OFF1L2) 996,996,997
00364         997 CONTINUE
00366         996 IF(1.EQ.H.ANO.CCHNL.EQ.1) RETURN1
00370             H=1
00371             UF=AMIN1(ABS(OEL1(H)),ABS(DEL2(H)))
00372             RETURN
00373        1000 1F(CCHNL.EQ.1) RETURN1
00375             RETURN
00376             END
```

Figure III-2. Continued.

```
                                                   0 *DIAGNOSTIC* MESSAGE(S)
HARM            SYMBOLIC                                     20 NOV 70  16:50:08   U  01577762   14   16K  (DELETED)
HARM     CODE   RELOCATABLE                                  15 DEC 70  06:10:42   1  01546756   30     1  (DELETED)
                                                                                   U  01547022   14    6U

    SUBROUTINE POWER      ENTRY POINT 000302

    STORAGE USED (BLOCK, NAME, LENGTH)

          0001     .CODE    000304
          0000     .DATA    000025
          0002     .BLANK   000000
          0003     NBLOCK   000317
          0004     TBLOCK   000320
          0005     PBLOCK   000074
          0006     ZBLOCK   000024


    EXTERNAL REFERENCES (BLOCK, NAME)

          0007     EXTRAC
          0010     ALOG10
          0011     NEAP6S
          0012     NERR3S


    STORAGE ASSIGNMENT FOR VARIABLES (BLOCK, TYPE, RELATIVE LOCATION, NAME)

     0001     000166 10L       0001     000224 20L       0001     000252 40L       0001     000240 70L       0001     000043 90L
     0001     000113 91L       0001     000136 92L       0001     000153 94L       0001     000273 999L      0003     000000 A
     0005     000000 AA        0003     000042 B         0005     000024 BB        0006     000007 BM        0003 R   000041 BR
     0004 R   000041 BIT       0004     000101 H2T       0003     000052 C         0006 I   000000 CCMNL     0003     000054 O
     0006     000005 OF        0006     000021 OFFIL1    0006     000022 OFFIL2    0006     000006 OF5       0006     000013 OF1
     0006     000014 OF2       0006     000015 OF3       0006     000016 OF4       0006     000017 OF8       0006     000020 OF6
     0000 R   000005 OPC       0003     000060 E         0007 I   000000 EXTRAC    0004     000042 F         0003     000101 FA
     0003     000102 FB        0004     000073 FC        0004     000074 FD        0003     000053 F1        0003     000040 FIF
     0006     000011 FIP       0003     000045 FIR       0004     000045 FIT       0006     000012 F2P       0003     000046 F2R
     0004     000046 F2T       0004     000060 G         0004     000064 GG        0005 I   000024 H         0006     000010 IMAGE
     0000     000015 INJPS     0000 I   000000 IP        0004 I   000072 IPCOMP    0000 I   000003 IPULSE    0000 I   000001 IPI
     0004 I   000043 IT36      0000 I   000004 JPULSE    0004 R   000047 KH        0003 R   000047 K1        0003 R   000050 KS
     0005 R   000023 LF        0006 R   000002 LF1       0006 R   000003 LF2       0006 R   000004 LF3       0003     000051 LOP
     0003 R   000044 M1        0003 R   000057 M2        0004 R   000044 N1        0004     000102 N11       0004 R   000057 N2
     0005     000027 FBL       0006 R   000001 PC        0000 R   000002 PI        0004 R   000063 PRT       0006 R   000023 P1
     0004     000000 Q         0004     000067 R         0003     000103 RBL       0004     000075 RR        0004 R   000066 TAU
     0004     000103 TBL


00101      1*          SUBROUTINE POWER
00103      2*          REAL M1,K1,KS,M2,N1,KH,N2,LF,LF1,LF2,LF3
00104      3*          INTEGER CCMNL
00105      4*          INTEGER H
```

Figure III-2.    Continued.

```
00106          INTEGER EXTRAC
00107          COMMON/RBLOCK/A(32),FIF,BR,B(2),N1,F1R,F2R,K1,KS,LOP,C,F1,O(3),H2,
00107         *E(17),FA,FB,RBL(140)
00110          COMMON/TBLOCK/W(33),BIT,F(11),IT36,NI,F1T,F2T,KH(8),N2,G(3),PRT,
00110         *GG(2),TAU,R(3),IPCOMP,FC,FO,RR(4),B2T,NI1,TBL(14))
00111          COMMON/PBLOCK/AA(19),LF,BB(2),H,PBL(37)
00111    C *** THIS COMMON BLOCK IS GENERATED BY OFR
00112          COMMON /ZBLOCK/CCHNL,PC,LF1,LF2,LF3,OF,OFS,BH,INAME,F1P,F2P,OF1,
00112         *OF2,OF3,OF4,OF5,OF6,OFFIL1,OFFIL2,PI
00113          DATA IP/1HP/IPI/1HC/
00116          DATA PI/3.1415927/
00120          IPULSE=EXTRAC(IT36,1)
00121          JPULSE=EXTRAC(IT36,2)
00122          PC=0.
00123          IF(IPCOMP.NE.IPI) GO TO 10
00123    C *** THE EQUIPMENT IS PULSE COMPRESSION
00125          IF(CCHNL.NE.1) GO TO 90
00127          IF(BR*BR*TAU/BIT-1.) 30,999,999
00132       30 PC=10.*ALOG10(BR*BR*TAU/BIT)
00133          GO TO 999
00134       90 IF(BIT/2.LT.1/(PI*PRT)) GO TO 91
00136          OPC=10.*ALOG10(BIT*TAU*(PRT/TAU)**P)*(2/(PI*BIT*PRT))**N2)
00137          GO TO 92
00140       91 OPC=10.*ALOG10(BIT*TAU*(2/(PI*BIT*TAU))**P))
00141       92 IF(BR*TAU-1.) 93,93,94
00144       93 PC= 10.*ALOG10(BR*TAU) + DPC
00145          GO TO 999
00146       94 PC= 10.*ALOG10(BR*TAU/2) + OPC
00147          GO TO 999
00150       10 IF(IPULSE.NE.IP.AND.JPULSE.NE.IP) GO TO 40
00150    C *** THE EQUIPMENT IS PULSED
00152          IF(CCHNL.NE.1) GO TO 20
00154          IF(BR*TAU-1.) 50,999,999
00157       50 PC=20.*ALOG10(BR*TAU)
00160          GO TO 999
00161       20 IF(BR*TAU-1.) 60,60,70
00164       60 PC=10.*ALOG10(BR*TAU)
00165          GO TO 999
00166       70 PC=10.*ALOG10(BR*TAU/2)
00167          GO TO 999
00167    C *** THE EQUIPMENT IS NEITHER PULSED NOR PULSE COMPRESSION
00170       40 IF(CCHNL.NE.1) GO TO 999
00172          IF(BR-BIT) 80,999,999
00175       80 PC=10.*ALOG10(BR/BIT)
00176      999 RETURN
00177          END
```

Figure III-2. Continued.

# APPENDIX IV

# AVPAK PROGRAM

The flow diagrams and FORTRAN V program listing for the overall AVPAK interference prediction program are contained in this Appendix. The flow diagram is shown in Figure IV-1, and the program listing is shown in Figure IV-2.

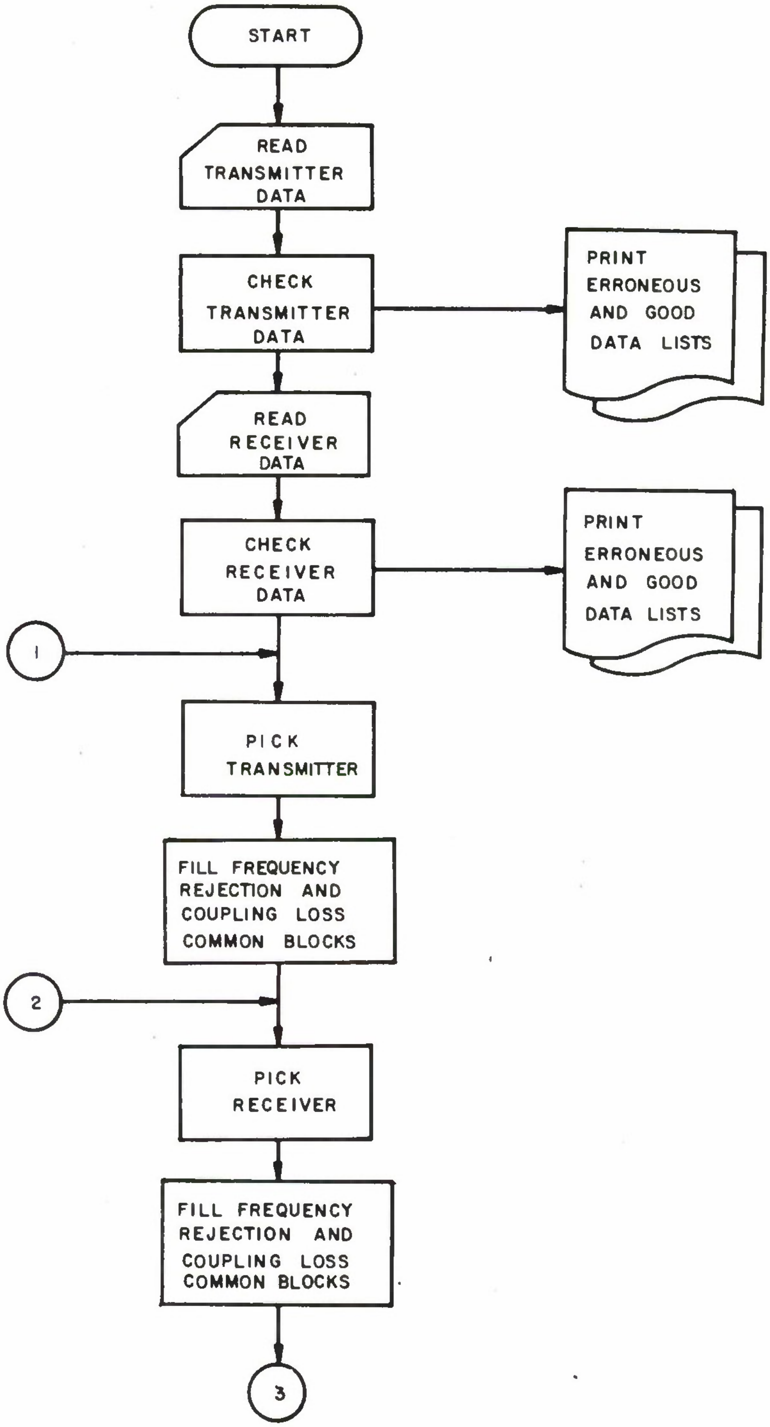


Figure IV-1. AVPAK Flow Diagram.

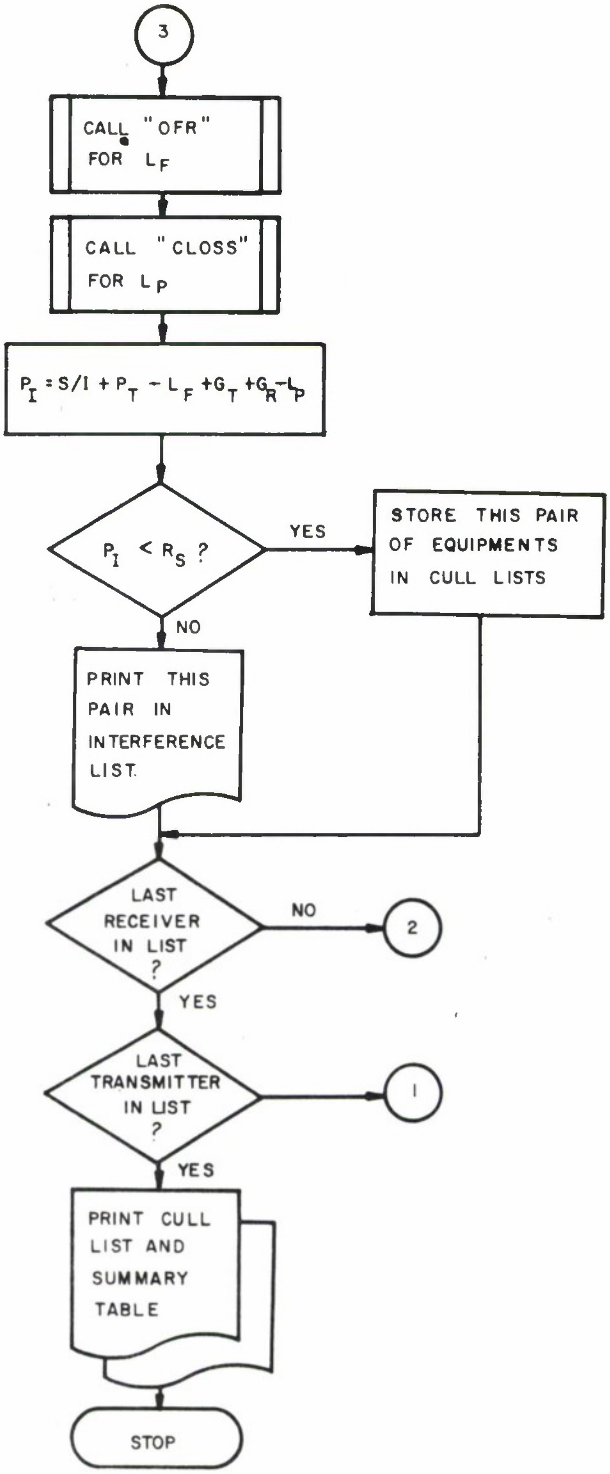


Figure IV-1. Continued.

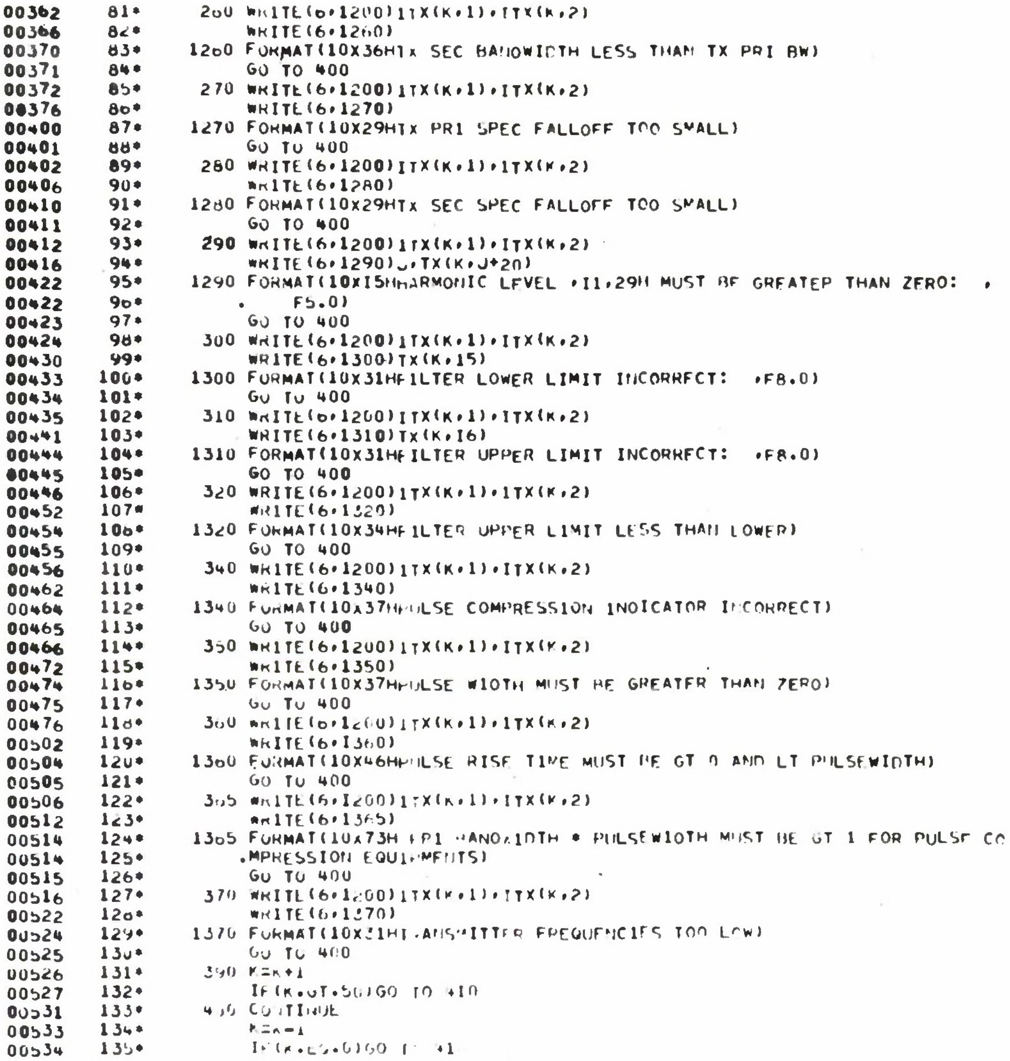
```
0000   040401 1990F    0001   000324 200L     0001   000343 210L     0001   000362 220L     0001   000165 224G
0001   000401 230L     0001   000417 240L     0001   000436 250L     0001   000455 260L     0001   000473 270L
0001   000511 280L     0001   000527 290L     0001   000555 300L     0001   000574 310L     0001   000613 320L
0001   000631 340L     0001   000647 350L     0001   000665 360L     0001   000703 365L     0001   000721 370L
0001   000737 390L     0001   000747 400L     0001   001075 410L     0001   001072 420L     0001   001103 500L
0001   001334 540L     0001   000772 542G     0001   001001 550G     0001   001010 556G     0001   001035 573G
0001   001344 600L     0001   001066 605G     0001   001361 610L     0001   001376 620L     0001   001126 627G
0001   001413 630L     0001   001150 635G     0001   001430 640L     0001   001160 642G     0001   001445 650L
0001   001462 660L     0001   001477 670L     0001   001514 680L     0001   001531 685L     0001   001546 690L
0001   001563 695L     0001   001600 697L     0001   001615 700L     0001   001625 710L     0001   000201 73L
0001   002256 780L     0001   002344 800L     0001   002457 805L     0001   002477 810L     0001   002502 815L
0001   002556 820L     0001   002560 821L     0001   000221 87L      0001   002737 910L     0001   002744 990L
0006 R 000003 ANGLE    0006 R 000005 ANTHT    0000 R 043264 BLANK    0006 R 000013 BULK     0000 R 001750 CULL
0006   000014 CURVE    0006 R 000001 DIST     0006 I 000017 ERR      0007 I 000000 EXTRAC   0006 R 000011 FNB
0006   000015 FREE     0000 R 037222 FREK     0006 R 000000 FREQ     0000 R 037227 GP       0000 R 037224 CT
0000 R 043261 HARM     0000 I 037213 I        0000 I 037202 IA       0000 I 037203 IB       0000 I 043264 IBLANK
0000 I 037204 IC       0000 I 043256 ID1      0000 I 043257 ID2      0000 I 037207 IN       0000 I 037201 IP
0000 I 037225 IREC     0000 I 043262 IR1      0000 I 043263 IR2      0003 I 000000 ITB      0000 I 037221 ITRAN
0000 I 040404 ITX      0000 I 037233 IT1      0000 I 037234 IT2      0000 I 037206 IX       0000 I 037205 IS
0000 I 037214 J        0000 I 037212 K        0006   000017 KERR     0000 I 037215 L        0000 I 043260 LOP
0000 I 037216 M        0000 I 037217 NCULL    0000 I 043261 NHARM    0000 I 037211 NR       0000 I 037210 NT
0000 I 037235 NTRAN1   0000 I 037236 NTRAN2   0000 I 037220 NWRITE   0000 R 037231 OFREJ    0005 R 000000 PBL
0000 R 037232 PI       0000 R 037223 PT       0000 I 032274 PTEST    0006 I 000007 RANT     0006 R 000012 PB
0004 R 000000 RBL      0000 R 043256 RID1     0000 R 043257 RID2     0000 R 043260 RLOP     0000 R 037226 FS
0000 R 000000 RX       0000 R 043262 R1       0000 R 043263 R2       0000 R 037230 SI       0003 R 000000 TBL
0006 R 000016 TCOUP    0000 I 032275 TOTAL    0000 R 040404 TX
```

```
00101              DIMENSION TX(50,29),RX(50,20),ITX(50,29),ITB(67),CULL(5,2500)
00103              INTEGER RANT,ERR,PTEST,EXTRAC,TOTAL(50,50)
00104              COMMON/TBLOCK/TBL(67)/RBLOCK/RBL(67)/PBLOCK/PBL(23)
00105              COMMON/CLCOMM/FREQ,DIST(2),ANGLE(2),ANTHT(2),RANT(2),
00105             .    FNB,RB,BULK,CURVE,FREE,TCOUP,KERR
00106              EQUIVALENCE (TX(1,1),ITX(1,1)),(TBL(1),ITB(1))
00107              EQUIVALENCE (ID1,RID1),(ID2,RID2),(LOP,RLOP),(NHARM,HARM)
00110              EQUIVALENCE (IR1,R1),(IR2,R2),(BLANK,IBLANK),(ERR,KERR)
00111              DATA IBLANK,IP,IA,IB,IC/1H ,1HP,1HA,1HB,1HC/
00117              DATA TOTAL/2500*1H /IX,IN/1HX,1HN/
00123              CALL INTRUP(0)
00124              READ(5,1000)NT,NR,FNB,RB
00132         1000 FORMAT(2(I2,3X),2(F6.0,4X))
00133              IF(NT.LT.1)GO TO 410
00135              K=1
00135        C
00135        C**   READ AND CHECK TRANSMITTER DATA
00135        C
00136              WRITE(6,1005)
00140         1005 FORMAT(1H1)
00141              DO 400 I=1,NT
00144              READ(5,1010)ITX(K,1),ITX(K,2),(TX(K,J),J=3,10),ITX(K,11),ITX(K,12)
00144             .    ,(TX(K,J),J=13,19),ITX(K,20),ITX(K,21),(TX(K,J),J=22,29)
00170         1010 FORMAT(2A6,2(1XF8.0),2(1XF6.0),2(1XF4.0),1XF3.0,1XF4.0,1XA3,1XA1,
00170             .    2(1XF4.0)/2(F6.0,1X),F5.0,1XF4.0,2(1XI1),6(1XF4.0))
```

Figure IV-2. AVPAK Program Listing.

```
00171        NHARM=ITX(K,21)
00172        IF(TX(K,3))210,210,25
00175     25 IF(TX(K,4))220,220,35
00200     35 IF(TX(K,4)-TX(K,3))230,50,50
00203     50 IF(TX(K,5))240,240,55
00206     55 IF(TX(K,6))250,250,60
00211     60 IF(TX(K,6)-TX(K,5))260,65,65
00214     65 IF(TX(K,7).LT.20.)GO TO 270
00216        IF(TX(K,8).LT.20.)GO TO 280
00220        IF(NHARM-1)200,73,68
00223     68 DO 70 J=2,NHARM
00226     70 IF(TX(K,J+20).LT.0.)GO TO 290
00231     73 IF(TX(K,15))300,87,80
00234     80 IF(TX(K,16))310,310,85
00237     85 IF(TX(K,16).LT.TX(K,15))GO TO 320
00241     87 PTEST=EXTRAC(ITX(K,11),1)
00242        IF(PTEST.NE.IP)GO TO 115
00244        IF(ITX(K,11).EQ.IBLANK)GO TO 110
00246        IF(ITX(K,12).EQ.IBLANK)GO TO 107
00250        IF(ITX(K,12).NE.IC)GO TO 340
00252        IF(TX(K,13)-TX(K,14))360,360,105
00255    105 IF(TX(K,14))360,360,107
00260    107 IF(TX(K,13))350,350,110
00263    110 IF(ITX(K,12).NE.IC)GO TO 115
00265        IF(TX(K,5)*TX(K,13)-1.)365,365,115
00270    115 FREQ=(TX(K,3)+TX(K,4))/2.
00271        IF(FREQ-30.)370,390,390
00271 C
00271 C**     TRANSMITTER DATA NOT GOOD.  WRITE ERROR MESSAGES AND SKIP THIS EQUIPMENT.
00271 C
00274    200 WRITE(6,1200)ITX(K,1),ITX(K,2)
00300   1200 FORMAT('0TRANSMITTER ',2A6,' HAS BEEN SKIPPED.')
00301        WRITE(6,1205)NHARM
00304   1205 FORMAT(10X30HILLEGAL NUMBER OF HARMONICS = ,I1)
00305        GO TO 400
00306    210 WRITE(6,1200)ITX(K,1),ITX(K,2)
00312        WRITE(6,1210)TX(K,3)
00315   1210 FORMAT(10X31HTX PRI FREQUENCY IS IN ERROR:  ,F8.0)
00316        GO TO 400
00317    220 WRITE(6,1200)ITX(K,1),ITX(K,2)
00323        WRITE(6,1220)TX(K,4)
00326   1220 FORMAT(10X31HTX SEC FREQUENCY IS IN ERROR:  ,F8.0)
00327        GO TO 400
00330    230 WRITE(6,1200)ITX(K,1),ITX(K,2)
00334        WRITE(6,1230)
00336   1230 FORMAT(10X43HTX SEC FREQUENCY LESS THAN TX PRI FREQUENCY)
00337        GO TO 400
00340    240 WRITE(6,1200)ITX(K,1),ITX(K,2)
00344        WRITE(6,1240)TX(K,5)
00347   1240 FORMAT(10X29HTX PRI BANDWIDTH INCORRECT:  ,F8.0)
00350        GO TO 400
00351    250 WRITE(6,1200)ITX(K,1),ITX(K,2)
00355        WRITE(6,1250)TX(K,6)
00360   1250 FORMAT(10X29HTX SEC BANDWIDTH INCORRECT:  ,F8.0)
00361        GO TO 400
```

Figure IV-2. Continued.



```
00362         260 WRITE(6,1200)ITX(K,1),ITX(K,2)
00366             WRITE(6,1260)
00370        1260 FORMAT(10X36HTX SEC BANDWIDTH LESS THAN TX PRI BW)
00371             GO TO 400
00372         270 WRITE(6,1200)ITX(K,1),ITX(K,2)
00376             WRITE(6,1270)
00400        1270 FORMAT(10X29HTX PRI SPEC FALLOFF TOO SMALL)
00401             GO TO 400
00402         280 WRITE(6,1200)ITX(K,1),ITX(K,2)
00406             WRITE(6,1280)
00410        1280 FORMAT(10X29HTX SEC SPEC FALLOFF TOO SMALL)
00411             GO TO 400
00412         290 WRITE(6,1200)ITX(K,1),ITX(K,2)
00416             WRITE(6,1290)J,TX(K,J+20)
00422        1290 FORMAT(10X15HHARMONIC LEVEL ,I1,29H MUST BE GREATER THAN ZERO:  ,
00422            .     F5.0)
00423             GO TO 400
00424         300 WRITE(6,1200)ITX(K,1),ITX(K,2)
00430             WRITE(6,1300)TX(K,15)
00433        1300 FORMAT(10X31HFILTER LOWER LIMIT INCORRECT:  ,F8.0)
00434             GO TO 400
00435         310 WRITE(6,1200)ITX(K,1),ITX(K,2)
00441             WRITE(6,1310)TX(K,16)
00444        1310 FORMAT(10X31HFILTER UPPER LIMIT INCORRECT:  ,F8.0)
00445             GO TO 400
00446         320 WRITE(6,1200)ITX(K,1),ITX(K,2)
00452             WRITE(6,1320)
00454        1320 FORMAT(10X34HFILTER UPPER LIMIT LESS THAN LOWER)
00455             GO TO 400
00456         340 WRITE(6,1200)ITX(K,1),ITX(K,2)
00462             WRITE(6,1340)
00464        1340 FORMAT(10X37HPULSE COMPRESSION INDICATOR INCORRECT)
00465             GO TO 400
00466         350 WRITE(6,1200)ITX(K,1),ITX(K,2)
00472             WRITE(6,1350)
00474        1350 FORMAT(10X37HPULSE WIDTH MUST BE GREATER THAN ZERO)
00475             GO TO 400
00476         360 WRITE(6,1200)ITX(K,1),ITX(K,2)
00502             WRITE(6,1360)
00504        1360 FORMAT(10X46HPULSE RISE TIME MUST BE GT 0 AND LT PULSEWIDTH)
00505             GO TO 400
00506         365 WRITE(6,1200)ITX(K,1),ITX(K,2)
00512             WRITE(6,1365)
00514        1365 FORMAT(10X73HTX PRI BANDWIDTH * PULSEWIDTH MUST BE GT 1 FOR PULSE CO
00514            .MPRESSION EQUIPMENTS)
00515             GO TO 400
00516         370 WRITE(6,1200)ITX(K,1),ITX(K,2)
00522             WRITE(6,1370)
00524        1370 FORMAT(10X31HTRANSMITTER FREQUENCIES TOO LOW)
00525             GO TO 400
00526         390 K=K+1
00527             IF(K.GT.50)GO TO 410
00531         400 CONTINUE
00533             K=K-1
00534             IF(K.EQ.0)GO TO 41
```

Figure IV-2. Continued.

```
00536         WRITE(6,1403)
00540    1403 FORMAT(1H1,50X'TRANSMITTERS WITH GOOD DATA'/'0TRANSMITTER  LOW FRE
00540        .Q  H1 FREQ  BW1   BW2     SF1   SF2    PT    GT MT PCI PW  PRT  LO
00540        .W FILT  HI FILT  Z-DIST  HEIGHT  ANGLE R H'/14X6(1H.),'(MHZ)',
00540        .    6(1H.), '  ...(KHZ)...  ..(DB/DEC)..  ...(DB)...      ..(US)..
00540        .   ....(MHZ).....      (IN)     (FT)   (DEG)'/)
00541         DO 405 I=1,K
00544         WRITE(6,1405)ITX(I,1),ITX(I,2),(TX(I,J),J=3,10),ITX(I,11),ITX(I,12
00544        .),  (TX(I,J),J=13,19),ITX(I,20),ITX(I,21)
00564    1405 FORMAT(1X2A6,2F9.0,2F7.0,  4F6.0,  A3,1XA1,  F5.1,1XF4,2,2F9.0,F8.
00564        .1,F7.2,3XF5.0,2(1XI1))
00565     405 CONTINUE
00567         WRITE(6,1415)
00571    1415 FORMAT('/',25X'TRANSMITTER HARMONICS'/21X1H2,10X1H3,10X1H4,10X1H5,
00571        .     10X1H6,10X1H7,10X1H8,10X1H9//)
00572         DO 420 I=1,K
00575         NHARM=ITX(I,21)
00576         IF(NHARM.LE.1)GO TO 420
00600         NHARM=NHARM+20
00601         WRITE(6,1420)ITX(I,1),ITX(1,2),(TX(I,J),J=22,NHARM)
00611    1420 FORMAT(1H ,2A6,8F11.0)
00612     420 CONTINUE
00614         GO TO 500
00615     410 WRITE(6,1410)
00617    1410 FORMAT(34H0NUMBER OF TRANSMITTERS IS ILLEGAL)
00620         GO TO 990
00621     500 L=1
00621   C
00621   C**     READ AND CHECK RECEIVER DATA
00621   C
00622         IF(NR.LT.1)GO TO 910
00624         WRITE(6,1005)
00626         DO 710 I=1,NR
00631         READ(5,1500)ID1,ID2,(RX(L,J),J=3,12),LOP,(RX(L,J),J=14,20)
00646    1500 FORMAT(2A6,2(1XF8.0),1XF6.0,3(1XF4.0),2(1XF3.0),2(1XF8.0),1XA1/
00646        .     F6.0,1XF5.0,1XF4.0,1XF1.0,1XF5.0,2(1XF4.0))
00647         IF(RX(L,3))600,600,505
00652     505 IF(RX(L,3).GT.99999.)GO TO 600
00654         IF(RX(L,4))610,610,510
00657     510 IF(RX(L,4).GT.99999.)GO TO 610
00661         IF(RX(L,4).LT.RX(L,3))GO TO 620
00663         IF(RX(L,5))630,630,515
00666     515 IF(RX(L,6))640,640,516
00671     516 IF(RX(L,6).GT.99999.)GO TO 640
00673         IF(RX(L,7).LT.20)GO TO 650
00675         IF(RX(L,8).LT.20)GO TO 660
00677         IF(RX(L,9).LT.0)GO TO 670
00701         IF(RX(L,10).LT.0)GO TO 680
00703         IF(RX(L,11))685,685,520
00706     520 IF(RX(L,11).GT.99999.)GO TO 685
00710         IF(RX(L,12))690,690,525
00713     525 IF(RX(L,12).GT.99999.)GO TO 690
00715         IF(RX(L,12)-RX(L,11))695,530,530
00720     530 IF(LOP.EQ.IA)GO TO 540
00722         IF(LOP.EQ.IB)GO TO 540
```

Figure IV-2. Continued.

```
00724            IF(LOP.NE.IC)GO TO 697
00726        540 RX(L,1)=RID1
00727            RX(L,2)=RID2
00730            RX(L,13)=RLOP
00731            GO TO 700
00731      C
00731      C**   RECEIVER DATA NOT GOOD.  WRITE ERROR MESSAGES AND SKIP THIS EQUIPMENT.
00731      C
00732        600 WRITE(6,1600)ID1,ID2
00736       1600 FORMAT('0RECEIVER ',2A6,' HAS BEEN SKIPPED.')
00737            WRITE(6,1605)
00741       1605 FORMAT(10X46HRX PRI FREQ MUST BE BETWEEN ZERO AND 99999 MHZ)
00742            GO TO 710
00743        610 WRITE(6,1600)ID1,ID2
00747            WRITE(6,I610)
00751       1610 FORMAT(10X46HRX SEC FREQ MUST BE BETWEEN ZERO AND 99999 MHZ)
00752            GO TO 710
00753        620 WRITE(6,1600)ID1,ID2
00757            WRITE(6,1620)
00761       1620 FORMAT(10X33HRX SEC FREQ LESS THAN RX PRI FREQ)
00762            GO TO 710
00763        630 WRITE(6,1600)ID1,ID2
00767            WRITE(6,1630)
00771       1630 FORMAT(10X38HRX BANDWIDTH MUST BE GREATER THAN ZERO)
00772            GO TO 710
00773        640 WRITE(6,1600)ID1,ID2
00777            WRITE(6,1640)
01001       1640 FORMAT(10X50HINTERMEDIATE FREQ MUST BE GT ZERO AND LE 99999 MHZ)
01002            GO TO 710
01003        650 WRITE(6,1600)ID1,ID2
01007            WRITE(6,1650)
01011       1650 FORMAT(10X33HRX PRI SPEC FALLOFF MUST BE GE 20)
01012            GO TO 710
01013        660 WRITE(6,1600)ID1,ID2
01017            WRITE(6,1660)
01021       1660 FORMAT(10X33HRX SEC SPEC FALLOFF MUST BE GE 20)
01022            GO TO 710
01023        670 WRITE(6,1600)ID1,ID2
01027            WRITE(6,1670)
01031       1670 FORMAT(10X27HIMAGE LEVEL MUST BE GE ZERO)
01032            GO TO 710
01033        680 WRITE(6,1600)ID1,ID2
01037            WRITE(6,1680)
01041       1680 FORMAT(10X30HSPURIOUS LEVEL MUST BE GE ZERO)
01042            GO TO 710
01043        685 WRITE(6,1600)ID1,ID2
01047            WRITE(6,1685)
01051       1685 FORMAT(10X51HRX LOWER OPER FREQ MUST BE GT ZERO AND LE 99999 MHZ)
01052            GO TO 710
01053        690 WRITE(6,1600)ID1,ID2
01057            WRITE(6,1690)
01061       1690 FORMAT(10X51HRX UPPER OPER FREQ MUST BE GT ZERO AND LE 99999 MHZ)
01062            GO TO 710
01063        695 WRITE(6,1600)ID1,ID2
01067            WRITE(6,1695)
```

Figure IV-2. Continued.

```
01071        1695 FORMAT(10X37HRX UPPER OPER FREQ LT LOWER OPER FREQ)
01072             GO TO 710
01073         697 WRITE(6,1600)ID1,ID2
01077             WRITE(6,1697)
01101        1697 FORMAT(10X44HLOCAL OSCILLATOR POSITION MUST BE A, B, OR C)
01102             GO TO 710
01103         700 L=L+1
01104             IF(L.GT.50)GO TO 910
01106         710 CONTINUE
01110             L=L-1
01111             IF(L.LE.0)GO TO 910
01113             WRITE(6,1710)
01115        1710 FORMAT('/',50X'RECEIVERS WITH GOOD DATA'/'0  RECEIVER  LOW FREQ  H
01115            .I FREQ    BW    IF    SF1     SF2  IM LEV SP LEV  LOW SRL  HI SRL LOP
01115            . Z-DIST  HT    ANG  R  SENS     GAIN   S/I'/13X'......(MHZ)......  (
01115            .KHZ)(MHZ) .(DB/DEC).  ....(DB).....  .....(MHZ).....          (IN)  (
01115            .FT) (DEG)      .........(DB).........'/)
01116             DO 715 I=1,L
01121             M=RX(I,17)
01122             RID1=RX(1,1)
01123             RID2=RX(1,2)
01124             RLOP=RX(I,13)
01125         715 WRITE(6,1715)ID1,ID2,(RX(I,J),J=3,12),LOP,(RX(I,J),J=14,16),
01125            .     M,(RX(I,J),J=18,20)
01150        1715 FORMAT(1X2A6,2F9.0,          3F6.0,3(1XF6.0),2F9.0,1XA1,F7.1,F6.2,
01150            .     F6.0,1X11,3F7.1)
01150       C
01150       C**   BEGIN ANALYSIS
01150       C
01151             NCULL=0
01152             NWRITE=3
01153             WRITE(6,1740)NT,NR,FNB,RB
01161        1740 FORMAT('1 NUMBER OF TRANSMITTERS   NUMBER OF RECEIVERS   KNIFE EDG
01161            .E LOCATION(INCHES)    KNIFE EDGE HEIGHT(FEET)'/11X12,21X12,22XF7.1
01161            .    ,20XF7.2)
01162             FNB=FNB/12.
01163             WRITE(6,1795)
01165        1795 FORMAT(        66H0EQUIPMENTS CAUSING POSSIBLE INTERFERENCE (POWER I
01165            .N GREATER THAN RECEIVER SENSITIVITY))
01166             WRITE(6,1809)
01170             DO 800 I=1,K
01173             WRITE(6,1793)
01175        1793 FORMAT(1H )
01176             NWRITE=NWRITE+1
01177             ID1=ITX(1,1)
01200             ID2=ITX(I,2)
01201             CALL MOVECH(ID1,I,2,1TRAN,I)
01202             TBL(38)=TX(I,3)
01203             TBL(39)=TX(I,4)
01204             TBL(34)=TX(1,5)/1000.
01205             TBL(66)=TX(I,6)/1000.
01206             TBL(37)=TX(I,7)
01207             TBL(48)=TX(1,8)
01210             ITB(36)=ITX(I,11)
01211             ITB(59)=ITX(I,12)
```

Figure IV-2. Continued.

```
01212    301*            TBL(55)=TX(I,13)
01213    302*            TBL(52)=TX(I,14)
01214    303*            TBL(60)=TX(I,15)
01215    304*            TBL(61)=TX(I,16)
01216    305*            ITB(67)=ITX(I,21)
01217    306*            FREK=(TBL(38)+TBL(39))/2.
01220    307*            DIST(1)=TX(I,17)/12.
01221    308*            ANTHT(1)=TX(I,18)
01222    309*            ANGLE(1)=TX(I,19)
01223    310*            RANT(1)=ITX(I,20)
01224    311*            PT=TX(I,9)
01225    312*            GT=TX(I,10)
01226    313*            DO 750 M=22,29
01231    314*        750 TBL(M+18)=TX(I,M)
01233    315*            DO 800 J=1,L
01236    316*            R1=RX(J,1)
01237    317*            R2=RX(J,2)
01240    318*            CALL MOVECH(IR1,1,2,IREC,1)
01241    319*            IF(ITRAN.EQ.IREC)GO TO 800
01243    320*            RBL(38)=RX(J,3)
01244    321*            RBL(39)=RX(J,4)
01245    322*            RBL(34)=RX(J,5)/1000.
01246    323*            RBL(33)=RX(J,6)
01247    324*            RBL(37)=RX(J,7)
01250    325*            RBL(48)=RX(J,8)
01251    326*            RBL(40)=RX(J,9)
01252    327*            RBL(41)=RX(J,10)
01253    328*            RBL(66)=RX(J,11)
01254    329*            RBL(67)=RX(J,12)
01255    330*            RBL(42)=RX(J,13)
01256    331*            DIST(2)=RX(J,14)/12.
01257    332*            ANTHT(2)=RX(J,15)
01260    333*            ANGLE(2)=RX(J,16)
01261    334*            RANT(2)=RX(J,17)
01262    335*            RS=RX(J,18)
01263    336*            GR=RX(J,19)
01264    337*            SI=RX(J,20)
01265    338*            CALL OFR
01266    339*            OFREJ=PBL(20)
01267    340*            HARM=PBL(23)
01270    341*            FREQ=FLOAT(NHARM)*FREK
01271    342*            CALL CLOSS
01272    343*            P1=S1+PT+OFREJ+GT+GR-TCOUP
01273    344*            IF(P1-RS)760,760,780
01276    345*        760 NCULL=NCULL+1
01277    346*            CULL(1,NCULL)=ERR
01300    347*            CALL PACK(CULL(2,NCULL),1+J*50,NHARM)
01301    348*            CULL(3,NCULL)=OFREJ
01302    349*            CULL(4,NCULL)=TCOUP
01303    350*            CULL(5,NCULL)=BULK
01304    351*            GO TO 800
01305    352*        780 WRITE(6,1780)ID1,ID2,IR1,IR2,S1,PT,OFREJ,GT,GR,TCOUP,PI,RS
01323    353*       1780 FORMAT(2(1X,2A6),2X4(F5.0,' + '),F5.0,' - ',F5.0,' = ',F5.0,
01323    354*          .     8XF5.0)
01324    355*            CALL MSG(NHARM)
```

Figure IV-2. Continued.

```
01325             TOTAL(I,J)=IX
01326             NWRITE=NWRITE+1
01327             ID1=IBLANK
01330             ID2=IBLANK
01331             IF(NWRITE.LE.45)GO TO 800
01333             ID1=ITX(I,I)
01334             ID2=ITX(I,2)
01335             WRITE(6,1005)
01337             WRITE(6,1795)
01341             WRITE(6,I809)
01343             NWRITE=0
01344         800 CONTINUE
01347             IF(NCULL.LE.0)GO TO 821
01351             WRITE(6,1800)
01353        1800 FORMAT(1H1,12X62HCULLED EQUIPMENTS (POWER IN IS LESS THAN RECEIVER
01353            . SENSITIVITY))
01354             WRITE(6;1810)
01356        1809 FORMAT('0TRANSMITTER  RECEIVER        S/I  +   PT  +   IF  +   GT
01356            .+    GR   -   LP   =   PI     >      RS . . . . . . REMARKS'//)
01357        I810 FORMAT('0TRANSMITTER  RECEIVER        S/I  +   PT  +   LF  +   GT
01357            .+    6R   -   LP   =   PI     <      RS . . . . . . REMARKS'//)
01360             NWRITE=0
01361             DO 820 M=I,NCULL
01364             ERR=CULL(1,M)
01365             CALL UNPACK(CULL(2,M),I,NHARM)
01366             J=I/50
01367             I=1-J*50
01370             RID1=RX(J,1)
01371             RID2=RX(J,2)
01372             BULK=CULL(5,M)
01373             PI=RX(J,20)+TX(I,9)+CULL(3,M)+TX(I,I0)+RX(J,19)-CULL(4,M)
01374             IF(IT1.NE.ITX(I,1))GO TO 805
01376             IF(IT2.NE.1TX(I,2))GO TO 805
01400             GO TO 810
01401         805 NTRAN1=ITX(I,I)
01402             NTRAN2=ITX(I,2)
01403             1T1=NTRAN1
01404             IT2=NTRAN2
01405             WRITE(6,1793)
01407             NWRITE=NWRITE+1
01410             GO TO 8I5
01411         810 NTRAN1=IBLANK
01412             NTRAN2=IBLANK
01413         815 WRITE(6,1780)NTRAN1,NTRAN2,ID1,ID2,RX(J,20),TX(I,9),CULL(3,M),
01413            .     TX(I,10),RX(J,I9),CULL(4,M),PI,RX(J,18)
01431             CALL MSG(NHARM)
01432             NWRITE=NWRITE+1
01433             IF(NWRITE.LT.45)GO TO 820
01435             WRITE(6,1800)
01437             WRITE(6,1810)
01441             NWRITE=0
01442             1TI=IBLANK
01443             1T2=IBLANK
01444         820 CONTINUE
01446         821 WRITE(6,1820)
```

Figure IV-2. Continued.

```
01450    411*     1820 FORMAT('1    TABLE OF INTERFERING EQUIPMENTS (X=INTERFERING)'/
01450    412*         .     '0TRANSMITTER',32X,'RECEIVERS',T117,'RECEIVER CODES'/)
01451    413*          RX(L+1,1)=BLANK
01452    414*          RX(L+1,2)=BLANK
01453    415*          DO 824 I=1,2
01456    416*          DO 822 J=1,L
01461    417*      822 ITB(J)=EXTRAC(RX(J,1),1)
01463    418*      824 WRITE(6,1822)(ITB(J),J=1,L)
01472    419*     1822 FORMAT(16X50A2)
01473    420*          WRITE(6,1823)
01475    421*     1823 FORMAT(' ',13X50(' .'))
01476    422*          DO 830 I=1,K
01501    423*          WRITE(6,1825)ITX(I,1),ITX(I,2),(TOTAL(I,J),J=1,L)
01511    424*     1825 FORMAT(1H0,2A6,3X50A2)
01512    425*      830 WRITE(6,1830)RX(I,1),RX(I,2)
01517    426*     1830 FORMAT(1H+,T119,2A6)
01520    427*          WRITE(6,1823)
01522    428*          K=K+1
01523    429*          IF(L.GE.K)WRITE(6,1832)((RX(I,J),J=1,2),I=K,L)
01535    430*     1832 FORMAT(1H0,T119,2A6)
01536    431*          GO TO 990
01537    432*      910 WRITE(6,1910)
01541    433*     1910 FORMAT(28H0ILLEGAL NUMBER OF RECEIVERS)
01542    434*      990 WRITE(6,1990)
01544    435*     1990 FORMAT(11H1END OF JOB)
01545    436*          STOP
01546    437*          END
```

Figure IV-2.   Continued.

```
SUBROUTINE MSG        ENTRY POINT 000077

STORAGE USED (BLOCK, NAME, LENGTH)

      0001   *CODE   000103
      0000   *DATA   000051
      0002   *BLANK  000000
      0003   CLCOMM  000020


EXTERNAL REFERENCES (BLOCK, NAME)

      0004   NERR2$
      0005   NWDU$
      0006   NIO2$
      0007   NERR3$


STORAGE ASSIGNMENT FOR VARIABLES (BLOCK, TYPE, RELATIVE LOCATION, NAME)

 0000    000000 1782F       0000   000007 1784F       0000   000015 1786F       0000   000023 1788F       0000   000031 1792F
 0000    000034 1794F       0001   000014 782L        0001   000022 784L        0001   000030 786L        0001   000036 788L
 0001    000043 790L        0003   000014 BUM         0003 R 000013 COUPK       0003   000000 DUMMY       0000   000042 INJP$
 0003 I  000017 KERR


00101      1*            SUBROUTINE MSG(NHARM)
00103      2*            COMMON/CLCOMM/DUMMY(11),COUPK,BUM(3),KERR
00104      3*            GO TO(790,782,784,786,790,788),KERR
00105      4*        782 WRITE(6,1782)
00107      5*       1782 FORMAT('+',109X'RAISED ANT NOT ANGLE 0')
00110      6*            GO TO 790
00111      7*        784 WRITE(6,1784)
00113      8*       1784 FORMAT('+',109X'ANTENNAS TOO CLOSE')
00114      9*            GO TO 790
00115     10*        786 WRITE(6,1786)
00117     11*       1786 FORMAT('+',109X'CURVE RANGE EXCEEDED')
00120     12*            GO TO 790
00121     13*        788 WRITE(6,1788)
00123     14*       1788 FORMAT('+',109X'BAD BULK HEAD HEIGHT')
00124     15*        790 IF(NHARM.GT.1)WRITE(6,1792)NHARM
00130     16*       1792 FORMAT(1H+,94X4HH = ,I1)
00131     17*            IF(COUPK.GT.0.)WRITE(6,1794)COUPK
00135     18*       1794 FORMAT('+',100X'LK=',F5.0)
00136     19*            END
```

Figure IV-2. Continued.

# APPENDIX V

## SABRELINER FIRST LEVEL ANALYSIS OUTPUT DATA

The output data obtained from automated portion of the first level analysis conducted during this study are shown in this Appendix.

```
                                                   TRANSMITTERS WITH GOOD DATA

TRANSMITTER  LOW FREQ  HI FREQ  BW1    BW2     SF1   SF2     PT     GT MT PCI PW  PRT   LOW FILT  HI FILT   Z-DIST  HEIGHT  ANGLE R H
             ......(MHZ)......  ...(KHZ)...  ..(DB/DEC)..  ...(DB)...      ..(US)..   ....(MHZ).....     (IN)    (FT)   (DEG)

01 WEATH RAD   9335.    9415.   190.    640.   20.    40.    73.   -10.PU     2.3 1.00    6560.   15000.     24.0     .10    180. 0 1
03 TAC2ABOVE   1025.    1150.   110.    260.   40.    40.    66.     2.P0     3.5 2.50      70.   10000.     44.0    1.00      0. 0 3
04 ATC XPNDR   1090.    1090.  1280.  12800.   20.    40.    57.     2.P0      .4  .05      70.   10000.     43.0    1.50    180. 0 3
05 TAC2BELOW   1025.    1150.   110.    260.   40.    40.    66.     2.P0     3.5 2.50      70.   10000.    110.0    3.14    180. 0 3
6A UHF COMM     225.     400.    12.    120.   80.    40.    45.     2.A3      .0  .00      70.    1000.    135.0    3.24    180. 0 3
6B VHF COMM2    118.     136.     6.     60.   80.    20.    44.     2.A3      .0  .00      70.     500.    135.0    3.24    180. 0 3
07 TAC1ABOVE   1025.    1150.   110.    260.   40.    40.    66.     2.PU     3.5 2.50      70.   10000.    146.0    3.27      0. 0 3
08 VHF COMM1    118.     136.     6.     60.   80.    20.    44.     2.A3      .0  .00      70.     500.    168.0    3.27      0. 0 3
09 DOPL RAD    8800.    8800. 10000.100000.   80.    20.    27.   -20.F2      .0  .00    6560.   10000.    190.0    3.27    180. 0 1
11 ALTIMETER   4300.    4300.140000.200000.  600.    20.    26.   -20.F9      .0  .00      70.   10000.    340.0    3.00    180. 0 2
12 TAC1BELOW   1025.    1150.   110.    260.   40.    40.    66.     2.P0     3.5 2.50      70.   10000.    377.0    2.52    180. 0 3

                           TRANSMITTER HARMONICS
                  2          3          4          5          6          7          8          9

03 TAC2ABOVE     60.        80.
04 ATC XPNDR     75.       120.
05 TAC2BELOW     60.        80.
6A UHF COMM     120.       130.
6B VHF COMM2     60.        80.
07 TAC1ABOVE     60.        80.
08 VHF COMM1     60.        80.
11 ALTIMETER     70.
12 TAC1BELOW     60.        80.
```

Figure V-1. AVPAK Output Data.

```
                                                  RECEIVERS WITH GOOD DATA

  RECEIVER    LOW FREQ  HI FREQ     B     IF     SF1     SF2   IM LEV SP LEV  LOW SRL  HI SRL LOP Z-DIST  HT   ANG  R  SENS     GAIN    S/T
             ......(MHZ)......  (KHZ)(MHZ) .(DB/DEC).  ....(DB).....  .....(MHZ).....       (IN)  (FT) (DEG)    ........(DB)........

 01 WEATH RAD   9335.     9415. 1000.   30.   100.    600.     60.     60.    6560.  10000. A   24.0   .10  180. 0 -104.0   -10.0    10.0
 02 GL1 SLOPE    329.      335.   80.   51.   100.     60.     70.     80.     200.    400. B    8.0   .64  180. 0 -101.0     2.0    20.0
 03 TAC 2A LF    962.     1024.  325.   63.    80.     40.     60.     60.     840.   1150. A   44.0  1.00    0. 0  -90.0     2.0    10.0
 03 TAC 2A HF   1151.     1213.  325.   63.    80.     40.     60.     60.    1030.   1330. B   44.0  1.00    0. 0  -90.0     2.0    10.0
 04 ATC XPNDR   1030.     1030. 6000.   60.    60.     70.     70.     70.     900.   1150. A   43.0  1.50  180. 0  -74.0     2.0    10.0
 05 TAC 2B LF    962.     1024.  325.   63.    80.     40.     60.     60.     840.   1150. A  110.0  3.14  180. 0  -90.0     2.0    10.0
 05 TAC 2B HF   1151.     1213.  325.   63.    80.     40.     60.     60.    1030.   1330. B  110.0  3.14  180. 0  -90.0     2.0    10.0
 06A UHF COMM    225.      400.   40.   30.   180.    100.    100.     80.     200.    450. B  135.0  3.27  180. 0  -97.0     2.0    10.0
 06B VHF COMM2   118.      136.   40.   17.   200.     80.    100.    100.     100.    156. B  135.0  3.27  180. 0  -97.0     2.0    10.0
 07 TAC 1A LF    962.     1024.  325.   63.    80.     40.     60.     60.     840.   1150. B  146.0  3.27    0. 0  -90.0     2.0    10.0
 07 TAC 1A HF   1151.     1213.  325.   63.    80.     40.     60.     60.    1030.   1330. B  146.0  3.27    0. 0  -90.0     2.0    10.0
 08 VHF COMM1    118.      136.   40.   17.   200.     80.    100.    100.     100.    156. B  168.0  3.27    0. 0  -97.0     2.0    10.0
 09 DOPL RAD    8800.     8800.  800.    5.   100.    600.      0.     80.    6560.  10000. A  190.0  3.27  180. 0 -120.0   -20.0    10.0
 10 MARK BEAC     75.       75.   40.    5.    70.     60.     60.     50.      70.     80. B  324.0  3.17  180. 0  -61.0    -5.0    10.0
 11 ALTIMETER   4300.     4300.  400.    0.    20.     80.     20.     70.    4100.   4500. B  370.0  2.64  180. 0  -73.0   -20.0    10.0
 12 TAC 1B LF    962.     1024.  325.   63.    80.     40.     60.     60.     840.   1150. A  377.0  2.52  180. 0  -90.0     2.0    10.0
 12 TAC 1B HF   1151.     1213.  325.   63.    80.     40.     60.     60.    1030.   1330. B  377.0  2.52  180. 0  -90.0     2.0    10.0
 13 UHF DIR F    225.      400.   40.   30.   180.    100.    100.     80.     200.    450. B  438.0  2.03  180. 0  -97.0     2.0    10.0
 14 VHF NAV1     108.      118.   40.   49.   200.     80.    100.    100.      90.    130. B  482.0  5.72    0. 1 -101.0     2.0    20.0
 15 VHF NAV2     108.      118.   40.   49.   200.     80.    100.    100.      90.    130. B  509.0  9.08    0. 1 -101.0     2.0    20.0
```

Figure V-1. Continued.

```
NUMBER OF TRANSMITTERS   NUMBER OF RECEIVERS   KNIFE EDGE LOCATION(INCHES)   KNIFE EDGE HEIGHT(FEET)
          11                      20                       36.0                        1.38

EQUIPMENTS CAUSING POSSIBLE INTERFERENCE (POWER IN GREATER THAN RECEIVER SENSITIVITY)

TRANSMITTER  RECEIVER       S/1  +   PT  +   LF  +   GT  +   GR  -   LP  =   P1   >     RS . . . . . . REMARKS


01 WEATH RAD 09 DOPL RAD    10. +   73. +  -80. + -10. +  -20. -   92. = -119.        -120.        LK=  27.

03 TAC2ABOVE 04 ATC XPNDR   10. +   66. +    0. +   2. +    2. -   62. =   18.         -74.
             05 TAC 2B LF   10. +   66. +  -48. +   2. +    2. -   68. =  -36.         -90.
             05 TAC 2B HF   10. +   66. +  -48. +   2. +    2. -   68. =  -36.         -90.
             07 TAC 1A LF   10. +   66. +  -48. +   2. +    2. -   41. =   -9.         -90.
             07 TAC 1A HF   10. +   66. +  -48. +   2. +    2. -   41. =   -9.         -90.
             12 TAC 1B LF   10. +   66. +  -48. +   2. +    2. -   66. =  -34.         -90.
             12 TAC 1B HF   10. +   66. +  -48. +   2. +    2. -   66. =  -34.         -90.

04 ATC XPNDR 02 GL1 SLOPE   20. +   57. + -129. +   2. +    2. -   39. =  -87.        -101.        LK=   6.
             03 TAC 2A LF   10. +   57. +  -75. +   2. +    2. -   62. =  -66.         -90.
             03 TAC 2A HF   10. +   57. +  -73. +   2. +    2. -   62. =  -64.         -90.
             05 TAC 2B LF   10. +   57. +  -75. +   2. +    2. -   39. =  -42.         -90.
             05 TAC 2B HF   10. +   57. +  -73. +   2. +    2. -   38. =  -40.         -90.
             07 TAC 1A LF   10. +   57. +  -75. +   2. +    2. -   73. =  -76.         -90.
             07 TAC 1A HF   10. +   57. +  -73. +   2. +    2. -   73. =  -75.         -90.
             12 TAC 1B LF   10. +   57. +  -75. +   2. +    2. -   52. =  -56.         -90.
             12 TAC 1B HF   10. +   57. +  -73. +   2. +    2. -   52. =  -54.         -90.

05 TAC2BELOW 02 GLI SLOPE   20. +   66. + -143. +   2. +    2. -   48. = -101.        -101.        LK=   6.
             03 TAC 2A LF   10. +   66. +  -48. +   2. +    2. -   68. =  -36.         -90.
             03 TAC 2A HF   10. +   66. +  -48. +   2. +    2. -   68. =  -36.         -90.
             04 ATC XPNDR   10. +   66. +    0. +   2. +    2. -   38. =   42.         -74.
             07 TAC 1A LF   10. +   66. +  -48. +   2. +    2. -   83. =  -51.         -90.
             07 TAC 1A HF   10. +   66. +  -48. +   2. +    2. -   83. =  -51.         -90.
             12 TAC 1B LF   10. +   66. +  -48. +   2. +    2. -   50. =  -18.         -90.
             12 TAC 1B HF   10. +   66. +  -48. +   2. +    2. -   50. =  -18.         -90.

6A UHF COMM  02 GL1 SLOPE   20. +   45. +    0. +   2. +    2. -   39. =   30.        -101.        LK=   6.
             6B VHF COMM2   10. +   45. + -152. +   2. +    2. -    0. =  -93.         -97.              ANTENNAS TOO CLOSE
             13 UHF DIR F   10. +   45. +    0. +   2. +    2. -   40. =   10.         -97.

6B VHF COMM2 6A UHF COMM    10. +   44. +  -60. +   2. +    2. -    0. =   -2.         -97. H = 2        ANTENNAS TOO CLOSE
             08 VHF COMM1   10. +   44. +    0. +   2. +    2. -   40. =   18.         -97.
             13 UHF DIR F   10. +   44. +  -60. +   2. +    2. -   38. =  -40.         -97. H = 2
             14 VHF NAV1    20. +   44. +  -75. +   2. +    2. -   40. =  -48.        -101.
             15 VHF NAV2    20. +   44. +  -75. +   2. +    2. -   40. =  -48.        -101.

07 TAC1ABOVE 03 TAC 2A LF   10. +   66. +  -48. +   2. +    2. -   41. =   -9.         -90.
             03 TAC 2A HF   10. +   66. +  -48. +   2. +    2. -   41. =   -9.         -90.
             04 ATC XPNDR   10. +   66. +    0. +   2. +    2. -   73. =    7.         -74.
```

Figure V-1. Continued

```
EQUIPMENTS CAUSING POSSIBLE INTERFERENCE (POWER IN GREATER THAN RECEIVER SENSITIVITY)

TRANSMITTER  RECEIVER        S/I  +   PT  +   LF  +   GT  +   GR  -   LP  =   P1    >    PS . . . . . . REMARKS

07 TAC1ABOVE 05 TAC 2B LF    10.  +   66. +  -48. +   2.  +   2.  -   83. =  -51.        -90.
             05 TAC 2B HF    10.  +   66. +  -48. +   2.  +   2.  -   83. =  -51.        -90.
             12 TAC 1B LF    10.  +   66. +  -48. +   2.  +   2.  -   77. =  -44.        -90.
             12 TAC 1B HF    10.  +   66. +  -48. +   2.  +   2.  -   77. =  -44.        -90.

08 VHF COMM1 6A UHF COMM     10.  +   44. +  -60. +   2.  +   2.  -   53. =  -55.        -97.  H = 2
             6E VHF COMM2    10.  +   44. +    0. +   2.  +   2.  -   41. =   17.        -97.
             13 UHF DIR F    10.  +   44. +  -60. +   2.  +   2.  -   50. =  -52.        -97.  H = 2
             14 VHF NAV1     20.  +   44. +  -75. +   2.  +   2.  -   33. =  -40.       -101.
             15 VHF NAV2     20.  +   44. +  -75. +   2.  +   2.  -   33. =  -41.       -101.


12 TAC1BELOW 03 TAC 2A LF    10.  +   66. +  -48. +   2.  +   2.  -   66. =  -34.        -90.
             03 TAC 2A HF    10.  +   66. +  -48. +   2.  +   2.  -   66. =  -34.        -90.
             04 ATC XPNDR    10.  +   66. +    0. +   2.  +   2.  -   52. =   28.        -74.
             05 TAC 2B LF    10.  +   66. +  -48. +   2.  +   2.  -   50. =  -18.        -90.
             05 TAC 2B HF    10.  +   66. +  -48. +   2.  +   2.  -   50. =  -18.        -90.
             07 TAC 1A LF    10.  +   66. +  -48. +   2.  +   2.  -   77. =  -44.        -90.
             07 TAC 1A HF    10.  +   66. +  -48. +   2.  +   2.  -   77. =  -44.        -90.
```

Figure V-1. Continued.

```
EQUIPMENTS CAUSING POSSIBLE INTERFERENCE (POWER IN GREATER THAN RECEIVER SENSITIVITY)

TRANSMITTER  RECEIVER          S/I  +   PT  +   LF  +   GT  +   GR  -   LP  =   PI     >     PS . . . . . . REMARKS


07 TAC1ABOVE 05 TAC 2B LF      10. +   66. +  -48. +    2. +    2. -   83. =  -51.          -90.
             05 TAC 2B HF      10. +   66. +  -48. +    2. +    2. -   83. =  -51.          -90.
             12 TAC 1B LF      10. +   66. +  -48. +    2. +    2. -   77. =  -44.          -90.
             12 TAC 1B HF      10. +   66. +  -48. +    2. +    2. -   77. =  -44.          -90.

08 VHF COMM1 0A UHF COMM       10. +   44. +  -60. +    2. +    2. -   53. =  -55.          -97. H = 2
             0B VHF COMM2      10. +   44. +    0. +    2. +    2. -   41. =   17.          -97.
             13 UHF DIR F      10. +   44. +  -60. +    2. +    2. -   50. =  -52.          -97. H = 2
             14 VHF NAV1       20. +   44. +  -75. +    2. +    2. -   33. =  -40.         -101.
             15 VHF NAV2       20. +   44. +  -75. +    2. +    2. -   33. =  -41.         -101.


12 TAC1BELOW 03 TAC 2A LF      10. +   66. +  -48. +    2. +    2. -   66. =  -34.          -90.
             03 TAC 2A HF      10. +   66. +  -48. +    2. +    2. -   66. =  -34.          -90.
             04 ATC XPNDR      10. +   66. +    0. +    2. +    2. -   52. =   28.          -74.
             05 TAC 2B LF      10. +   66. +  -48. +    2. +    2. -   50. =  -18.          -90.
             05 TAC 2B HF      10. +   66. +  -48. +    2. +    2. -   50. =  -18.          -90.
             07 TAC 1A LF      10. +   66. +  -48. +    2. +    2. -   77. =  -44.          -90.
             07 TAC 1A HF      10. +   66. +  -48. +    2. +    2. -   77. =  -44.          -90.
```

Figure V-1. Continued.

```
                CULLED EQUIPMENTS (POWER IN IS LESS THAN RECEIVER SENSITIVITY)

TRANSMITTER  RECEIVER        S/I  +   PT  +   LF  +   GT  +   GP  -   LP  =   PI    <     RS . . . . . . . REMARKS


01 WEATH RAD 02 GLI SLOPE    20. +   73. + -212. + -10. +    2. -   44. = -171.         -101.
             03 TAC 2A LF    10. +   73. + -133. + -10. +    2. -   74. = -132.          -90.         LK=  27.
             03 TAC 2A HF    10. +   73. + -134. + -10. +    2. -   74. = -133.          -90.         LK=  27.
             04 ATC XPNDR    10. +   73. + -199. + -10. +    2. -   69. = -193.          -74.         LK=  21.
             05 TAC 2B LF    10. +   73. + -133. + -10. +    2. -   85. = -143.          -90.         LK=  25.
             05 TAC 2B HF    10. +   73. + -134. + -10. +    2. -   85. = -143.          -90.         LK=  25.
             6A UHF COMM     10. +   73. + -312. + -10. +    2. -   88. = -325.          -97.         LK=  26.
             6B VHF COMM2    10. +   73. + -320. + -10. +    2. -   88. = -332.          -97.         LK=  26.
             07 TAC 1A LF    10. +   73. + -133. + -10. +    2. -   90. = -148.          -90.         LK=  28.
             07 TAC 1A HF    10. +   73. + -134. + -10. +    2. -   90. = -149.          -90.         LK=  28.
             08 VHF COMM1    10. +   73. + -320. + -10. +    2. -   92. = -336.          -97.         LK=  28.
             10 MARK BEAC    10. +   73. + -253. + -10. +   -5. -   98. = -282.          -61.         LK=  28.
             11 ALTIMETER    10. +   73. + -182. + -10. +  -20. -   99. = -228.          -73.         LK=  28.
             12 TAC 1B LF    10. +   73. + -133. + -10. +    2. -   99. = -157.          -90.         LK=  28.
             12 TAC 1B HF    10. +   73. + -134. + -10. +    2. -   99. = -158.          -90.         LK=  28.
             13 UHF DIR F    10. +   73. + -312. + -10. +    2. -  101. = -338.          -97.         LK=  28.
             14 VHF NAV1     20. +   73. + -337. + -10. +    2. -  102. = -355.         -101.         LK=  29.
             15 VHF NAV2     20. +   73. + -337. + -10. +    2. -  103. = -355.         -101.         LK=  29.

03 TAC2ABOVE 01 WEATH RAD    10. +   66. + -252. +   2. +  -10. -   55. = -240.         -104. H = 2 LK=  20.
             02 GLI SLOPE    20. +   66. + -143. +   2. +    2. -   50. = -103.         -101.         LK=  17.
             6A UHF COMM     10. +   66. + -175. +   2. +    2. -   68. = -163.          -97.
             6B VHF COMM2    10. +   66. + -181. +   2. +    2. -   68. = -170.          -97.
             08 VHF COMM1    10. +   66. + -181. +   2. +    2. -   43. = -144.          -97.
             09 DOPL RAD     10. +   66. + -253. +   2. +  -20. -   81. = -276.         -120. H = 2
             10 MARK BEAC    10. +   66. + -182. +   2. +   -5. -   67. = -177.          -61.
             11 ALTIMETER    10. +   66. + -173. +   2. +  -20. -   85. = -200.          -73. H = 3
             13 UHF DIR F    10. +   66. + -175. +   2. +    2. -   65. = -160.          -97.
             14 VHF NAV1     20. +   66. + -182. +   2. +    2. -   54. = -146.         -101.
             15 VHF NAV2     20. +   66. + -182. +   2. +    2. -   55. = -146.         -101.

04 ATC XPNDR 01 WEATH RAD    10. +   57. + -221. +   2. +  -10. -   50. = -213.         -104. H = 2 LK=  15.
             6A UHF COMM     10. +   57. + -134. +   2. +    2. -   41. = -103.          -97.
             6B VHF COMM2    10. +   57. + -139. +   2. +    2. -   41. = -109.          -97.
             08 VHF COMM1    10. +   57. + -139. +   2. +    2. -   72. = -141.          -97.
             09 DOPL RAD     10. +   57. + -222. +   2. +  -20. -   51. = -224.         -120. H = 2
             10 MARK BEAC    10. +   57. + -141. +   2. +   -5. -   50. = -127.          -61.
             11 ALTIMETER    10. +   57. + -214. +   2. +  -20. -   61. = -226.          -73. H = 3
             13 UHF DIR F    10. +   57. + -134. +   2. +    2. -   53. = -116.          -97.
             14 VHF NAV1     20. +   57. + -140. +   2. +    2. -   61. = -120.         -101.
             15 VHF NAV2     20. +   57. + -140. +   2. +    2. -   62. = -121.         -101.

05 TAC2BELOW 01 WEATH RAD    10. +   66. + -252. +   2. +  -10. -   66. = -250.         -104. H = 2 LK=  19.
             6A UHF COMM     10. +   66. + -175. +   2. +    2. -   29. = -124.          -87.
```

Figure V-1. Continued.

```
                CULLED EQUIPMENTS (POWER IN IS LESS THAN RECEIVER SENSITIVITY)

TRANSMITTER  RECEIVER        S/1  +   PT  +   LF  +   GT  +   GR  -   LP  =   PI    <     RS . . . . . . REMARKS


05 TAC2BELOW 08 VHF COMM2    10. +   66. + -181. +   2. +    2. -   29. = -131.        -97.
             08 VHF COMM1    10. +   66. + -181. +   2. +    2. -   83. = -184.        -97.
             09 DOPL RAD     10. +   66. + -253. +   2. +  -20. -   45. = -240.       -120. H = 2
             10 MARK BEAC    10. +   66. + -162. +   2. +   -5. -   48. = -157.        -61.
             11 ALTIMETER    10. +   66. + -173. +   2. +  -20. -   59. = -174.        -73. H = 3
             13 UHF DIR F    10. +   66. + -175. +   2. +    2. -   52. = -147.        -97.
             14 VHF NAV1     20. +   66. + -182. +   2. +    2. -   69. = -160.       -101.
             15 VHF NAV2     20. +   66. + -182. +   2. +    2. -   68. = -160.       -101.

6A UHF COMM  01 WEATH RAD    10. +   45. + -387. +   2. +  -10. -   52. = -392.       -104. H = 2 LK=  14.
             03 TAC 2A LF    10. +   45. + -185. +   2. +    2. -   57. = -183.        -90. H = 2
             03 TAC 2A HF    10. +   45. + -199. +   2. +    2. -   57. = -197.        -90. H = 2
             04 ATC XPNDR    10. +   45. + -207. +   2. +    2. -   36. = -184.        -74. H = 2
             05 TAC 2B LF    10. +   45. + -185. +   2. +    2. -   24. = -150.        -90. H = 2
             05 TAC 2B HF    10. +   45. + -199. +   2. +    2. -   24. = -164.        -90. H = 2
             07 TAC 1A LF    10. +   45. + -185. +   2. +    2. -   71. = -197.        -90. H = 2
             07 TAC 1A HF    10. +   45. + -199. +   2. +    2. -   71. = -210.        -90. H = 2
             06 VHF COMM1    10. +   45. + -152. +   2. +    2. -   56. = -149.        -97.
             09 DOPL RAD     10. +   45. + -387. +   2. +  -20. -   31. = -381.       -120. H = 2
             10 MARK BEAC    10. +   45. + -139. +   2. +   -5. -   36. = -123.        -61.
             11 ALTIMETER    10. +   45. + -289. +   2. +  -20. -   44. = -296.        -73. H = 2
             12 TAC 1B LF    10. +   45. + -185. +   2. +    2. -   44. = -170.        -90. H = 2
             12 TAC 1B HF    10. +   45. + -199. +   2. +    2. -   44. = -184.        -90. H = 2
             14 VHF NAV1     20. +   45. + -176. +   2. +    2. -   51. = -158.       -101.
             15 VHF NAV2     20. +   45. + -176. +   2. +    2. -   51. = -158.       -101.

6B VHF COMM2 01 WEATH RAD    10. +   44. + -227. +   2. +  -10. -   41. = -222.       -104. H = 2 LK=  11.
             02 GL1 SLOPE    20. +   44. + -160. +   2. +    2. -   40. = -132.       -101. H = 3 LK=   6.
             03 TAC 2A LF    10. +   44. + -150. +   2. +    2. -   43. = -135.        -90. H = 2
             03 TAC 2A HF    10. +   44. + -154. +   2. +    2. -   43. = -140.        -90. H = 2
             04 ATC XPNDR    10. +   44. + -164. +   2. +    2. -   28. = -154.        -74. H = 2
             05 TAC 2B LF    10. +   44. + -150. +   2. +    2. -   17. = -109.        -90. H = 2
             05 TAC 2B HF    10. +   44. + -154. +   2. +    2. -   17. = -113.        -90. H = 2
             07 TAC 1A LF    10. +   44. + -150. +   2. +    2. -   53. = -145.        -90. H = 2
             07 TAC 1A HF    10. +   44. + -154. +   2. +    2. -   53. = -149.        -90. H = 2
             09 DOPL RAD     10. +   44. + -228. +   2. +  -20. -   23. = -215.       -120. H = 2
             10 MARK BEAC    10. +   44. + -106. +   2. +   -5. -   28. =  -83.        -61.
             11 ALTIMETER    10. +   44. + -224. +   2. +  -20. -   36. = -224.        -73. H = 2
             12 TAC 1B LF    10. +   44. + -150. +   2. +    2. -   36. = -128.        -90. H = 2
             12 TAC 1B HF    10. +   44. + -154. +   2. +    2. -   36. = -133.        -90. H = 2

07 TAC1ABOVE 01 WEATH RAD    10. +   66. + -252. +   2. +  -10. -   71. = -255.       -104. H = 2 LK=  22.
             02 GL1 SLOPE    20. +   66. + -143. +   2. +    2. -   60. = -113.       -101.       LK=  15.
             6A UHF COMM     10. +   66. + -175. +   2. +    2. -   84. = -179.        -97.
```

Figure V-1. Continued.

```
          CULLED EQUIPMENTS (POWER IN IS LESS THAN RECEIVER SENSITIVITY)

TRANSMITTER  RECEIVER        S/1  +   PT  +   LF  +   GT  +   GP  -   LP  =   PI    <     PS . . . . . . . REMARKS


07 TAC1ABOVE 08 VHF COMM2    10. +   66. + -181. +    2. +    2. -   84. = -185.         -97.
             08 VHF COMM1    10. +   66. + -181. +    2. +    2. -   28. = -129.         -97.
             09 DOPL RAD     10. +   66. + -253. +    2. +  -20. -  103. = -297.        -120. H = 2
             10 MARK BEAC    10. +   66. + -182. +    2. +   -5. -   80. = -189.         -61.
             11 ALTIMETER    10. +   66. + -173. +    2. +  -20. -  103. = -217.         -73. H = 3
             13 UHF DIR F    10. +   66. + -175. +    2. +    2. -   74. = -169.         -97.
             14 VHF NAV1     20. +   66. + -182. +    2. +    2. -   52. = -143.        -101.
             15 VHF NAV2     20. +   66. + -182. +    2. +    2. -   53. = -144.        -101.

08 VHF COMM1 01 WEATH RAD    10. +   44. + -227. +    2. +  -10. -   45. = -226.        -104. H = 2 LK=  13.
             02 GLI SLOPE    20. +   44. + -160. +    2. +    2. -   48. = -140.        -101. H = 3 LK=  12.
             03 TAC 2A LF    10. +   44. + -150. +    2. +    2. -   31. = -123.         -90. H = 2
             03 TAC 2A HF    10. +   44. + -154. +    2. +    2. -   31. = -127.         -90. H = 2
             04 ATC XPNDR    10. +   44. + -184. +    2. +    2. -   46. = -172.         -74. H = 2
             05 TAC 2B LF    10. +   44. + -150. +    2. +    2. -   52. = -144.         -90. H = 2
             05 TAC 2B HF    10. +   44. + -154. +    2. +    2. -   52. = -148.         -90. H = 2
             07 TAC 1A LF    10. +   44. + -150. +    2. +    2. -   15. = -108.         -90. H = 2
             07 TAC 1A HF    10. +   44. + -154. +    2. +    2. -   15. = -112.         -90. H = 2
             09 DOPL RAD     10. +   44. + -228. +    2. +  -20. -   53. = -244.        -120. H = 2
             10 MARK BEAC    10. +   44. + -106. +    2. +   -5. -   42. =  -97.         -61.
             11 ALTIMETER    10. +   44. + -224. +    2. +  -20. -   51. = -239.         -73. H = 2
             12 TAC 1B LF    10. +   44. + -150. +    2. +    2. -   51. = -143.         -90. H = 2
             12 TAC 1B HF    10. +   44. + -154. +    2. +    2. -   51. = -147.         -90. H = 2

09 DOPL RAD  01 WEATH RAD    10. +   27. +  -69. +  -20. +  -10. -   91. = -153.        -104.       LK=  27.
             02 GLI SLOPE    20. +   27. + -228. +  -20. +    2. -   78. = -277.        -101.       LK=  13.
             03 TAC 2A LF    10. +   27. + -146. +  -20. +    2. -  117. = -244.         -90.
             03 TAC 2A HF    10. +   27. + -147. +  -20. +    2. -  117. = -245.         -90.
             04 ATC XPNDR    10. +   27. + -199. +  -20. +    2. -   63. = -243.         -74.
             05 TAC 2B LF    10. +   27. + -146. +  -20. +    2. -   58. = -185.         -90.
             05 TAC 2B HF    10. +   27. + -147. +  -20. +    2. -   58. = -186.         -90.
             6A UHF COMM     10. +   27. + -327. +  -20. +    2. -   54. = -362.         -97.
             08 VHF COMM2    10. +   27. + -335. +  -20. +    2. -   54. = -370.         -97.
             07 TAC 1A LF    10. +   27. + -146. +  -20. +    2. -  148. = -276.         -90.
             07 TAC 1A HF    10. +   27. + -147. +  -20. +    2. -  148. = -277.         -90.
             08 VHF COMM1    10. +   27. + -335. +  -20. +    2. -  149. = -465.         -97.
             10 MARK BEAC    10. +   27. + -268. +  -20. +   -5. -   62. = -318.         -61.
             11 ALTIMETER    10. +   27. + -192. +  -20. +  -20. -   65. = -260.         -73.
             12 TAC 1B LF    10. +   27. + -146. +  -20. +    2. -   65. = -192.         -90.
             12 TAC 1B HF    10. +   27. + -147. +  -20. +    2. -   65. = -193.         -90.
             13 UHF DIR F    10. +   27. + -327. +  -20. +    2. -   67. = -375.         -97.
             14 VHF NAV1     20. +   27. + -353. +  -20. +    2. -  113. = -437.        -101.
             15 VHF NAV2     20. +   27. + -353. +  -20. +    2. -  110. = -434.        -101.

11 ALTIMETER 01 WEATH RAD    10. +   26. + -151. +  -20. +  -10. -   97. = -242.        -104. H = 2 LK=  28.
```

Figure V-1. Continued.

```
                 CULLED EQUIPMENTS (POWER IN IS LESS THAN RECEIVER SENSITIVITY)

TRANSMITTER  RECEIVER        S/1  +   PT  +   LF  +   GT  +   GR  -   LP  =   PI   <    RS . . . . . . REMARKS


11 ALTIMETER 02 GL1 SLOPE     20. +   26. + -157. +  -20. +    2. -   78. = -207.       -101.         LK=  14.
             03 TAC 2A LF     10. +   26. + -143. +  -20. +    2. -   92. = -217.        -90.
             03 TAC 2A HF     10. +   26. + -143. +  -20. +    2. -   92. = -217.        -90.
             04 ATC XPNDR     10. +   26. + -137. +  -20. +    2. -   63. = -182.        -74.
             05 TAC 2B LF     10. +   26. + -143. +  -20. +    2. -   60. = -185.        -90.
             05 TAC 2B HF     10. +   26. + -143. +  -20. +    2. -   60. = -186.        -90.
             6A UHF COMM      10. +   26. + -160. +  -20. +    2. -   59. = -202.        -97.
             6B VHF COMM2     10. +   26. + -161. +  -20. +    2. -   59. = -202.        -97.
             07 TAC 1A LF     10. +   26. + -143. +  -20. +    2. -  114. = -239.        -90.
             07 TAC 1A HF     10. +   26. + -143. +  -20. +    2. -  114. = -239.        -90.
             08 VHF COMM1     10. +   26. + -161. +  -20. +    2. -  115. = -258.        -97.
             09 DOPL RAD      10. +   26. + -172. +  -20. +  -20. -   63. = -239.       -120. H = 2
             10 MARK BEAC     10. +   26. + -161. +  -20. +   -5. -   37. = -187.        -61.
             12 TAC 1B LF     10. +   26. + -143. +  -20. +    2. -   45. = -170.        -90.
             12 TAC 1B HF     10. +   26. + -143. +  -20. +    2. -   45. = -170.        -90.
             13 UHF DIR F     10. +   26. + -160. +  -20. +    2. -   53. = -195.        -97.
             14 VHF NAV1      20. +   26. + -161. +  -20. +    2. -   96. = -220.       -101.
             15 VHF NAV2      20. +   26. + -161. +  -20. +    2. -   93. = -226.       -101.

12 TAC1BELOW 01 WEATH RAD     10. +   66. + -252. +    2. +  -10. -   80. = -264.       -104. H = 2 LK=  22.
             02 GL1 SLOPE     20. +   66. + -143. +    2. +    2. -   62. = -115.       -101.       LK=   9.
             6A UHF COMM      10. +   66. + -175. +    2. +    2. -   49. = -144.        -97.
             6B VHF COMM2     10. +   66. + -181. +    2. +    2. -   49. = -150.        -97.
             08 VHF COMM1     10. +   66. + -181. +    2. +    2. -   77. = -178.        -97.
             09 DOPL RAD      10. +   66. + -253. +    2. +  -20. -   53. = -248.       -120. H = 2
             10 MARK BEAC     10. +   66. + -182. +    2. +   -5. -   36. = -145.        -61.
             11 ALTIMETER     10. +   66. + -173. +    2. +  -20. -   29. = -142.        -73. H = 3
             13 UHF DIR F     10. +   66. + -175. +    2. +    2. -   37. = -132.        -97.
             14 VHF NAV1      20. +   66. + -182. +    2. +    2. -   64. = -155.       -101.
             15 VHF NAV2      20. +   65. + -182. +    2. +    2. -   64. = -156.       -101.
```

Figure V-1. Continued.

```
      TABLE OF INTERFERING EQUIPMENTS (X=INTERFERING)
TRANSMITTER                            RECEIVERS                        RECEIVER CODES

                 0 0 0 0 0 0 0 6 6 0 0 0 0 1 1 1 1 1 1 1
                 1 2 3 3 4 5 5 A B 7 7 8 9 0 1 2 2 3 4 5
                 . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
01 WEATH RAD                             X                                  01 WEATH RAD
03 TAC2ABOVE             X X X     X X         X X                          02 GLI SLOPE
04 ATC XPNDR       X X X   X X     X X         X X                          03 TAC 2A LF
05 TAC2BELOW       X X X X         X X         X X                          03 TAC 2A HF
6A UHF COMM        X             X                 X                        04 ATC XPNDR
6B VHF COMM2                   X       X           X X X                    05 TAC 2B LF
07 TAC1ABOVE           X X X X X                 X X                        05 TAC 2B HF
08 VHF COMM1                   X X                 X X X                    6A UHF COMM
09 DOPL RAD                                                                 6B VHF COMM2
11 ALTIMETER                                                                07 TAC 1A LF
12 TAC1BELOW           X X X X X     X X                                    07 TAC 1A HF
                 . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
                                                                            08 VHF COMM1
                                                                            09 DOPL RAD
                                                                            10 MARK BEAC
                                                                            11 ALTIMETER
                                                                            12 TAC 1B LF
                                                                            12 TAC 1B HF
                                                                            13 UHF DIR F
                                                                            14 VHF NAV1
                                                                            15 VHF NAV2
```

Figure V-1. Continued.

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ABSTRACT

An interference prediction model developed for use in evaluating expected interactions between avionics equipments on an airplane is described. The model is substantially automated and includes subroutines which calculate expected path losses between aircraft antennas and the rejection offered by the receivers to the undesired emissions from transmitters on the aircraft.

An analysis of the interactions between the equipments installed on an FAA Sabreliner has been made using the prediction model and the results of the analysis are described.

Requirements for expansion of the prediction model are established.

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